



ROBERT HARTIG

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ROBERT HARTIG

(1839-1901)

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WITH PORTRAIT, PLATE I

In our era of specialization, that curse and blessing of modern research, we look up, with amazement and admiration, to those universally trained men of by-gone generations, who, as well trained in speculative philosophy as in all branches of scientific endeavor, were capable of producing as thorough work in botany as in mathematics, in entomology as in astronomy. Leonardo da Vinci and Goethe, artists, poets, philosophers and scientists at the same time, are types impossible in our days. The times of a Humboldt, Schleiden or Darwin have passed forever. The second half of the last century has brought that splitting up of disciplines into innumerable, everbranching specialties, which has resulted in unheard-of triumphs of research on one side and in the most short-sighted narrowness of conception on the other. *Robert Hartig* and his contemporaries, as a type, form the connecting link between the old and the modern school. Born in 1839 (Brunswick, Germany, May 30) he grew up in the ideals of universality. Throughout his work in later life, highly specialized though it was, these ideals saved him from losing sight of the really big issues, from mistaking digging for creation. Discipline of mind, the result of the thorough and broad, often even pedantic, schooling which formed an integral part of the pedagogic system of the period, preserved him from superficiality.

Robert Hartig was the last issue of a family of scientists. His grandfather, Georg Ludwig Hartig, chief forester of Prussia, laid the scientific foundations of modern silviculture. Georg Ludwig's son, Theodor Hartig, one of the great foresters of his times, well known through his work on the theory of yield, is known in botany by his discovery of aleuron and his writings on a great number of botanical subjects.

In this atmosphere of research Robert Hartig grew up. Family tradition and early training brought him in touch with the scientific problems of his period and laid that broad foundation of solid knowledge and clear understanding which served him so well in later life.

Robert Hartig received his college training at the University of Berlin. In 1864 he entered the Brunswick Government Service. The routine and narrowness of mind which he encountered there were not to his taste. He soon resigned his position to go back to University work. He took his doctor's degree at Marburg and went into forestry work. In the midst of this activity he was sent to the Forest Academy at Eberswalde, where he was to lecture during the illness of Professor Ratzeburg. Inside of four days he began with his customary energy, though quite unprepared, his lectures on Botany and Zoology.

This step was decisive for the further course of his life. From that time on his activities were devoted to University teaching and research. From 1866 to 1878 Hartig taught at Eberswalde. Although deeply interested in zoological problems, he soon turned to Botany, particularly to questions with a strong bearing on forestry. Some of his most important works were written at Eberswalde. His "Wichtige Krankheiten der Waldbäume" and "Zersetzungerscheinungen des Holzes der Nadelholzbäume und der Eiche" are fundamental. In 1878 he was called to Munich, Bavaria, as Professor of Botany and Head of the Botanical Department of the recently founded Royal Forestry Experiment Station, where he remained to the end of his life. The intellectual atmosphere of Munich and the liberal attitude of the Bavarian Government in contrast to the stricter tone of Eberswalde made him feel at home at once in the Bavarian capital. A period of intense and fruitful work began, only to end with his death. In regular succession a stream of books and papers poured from his laboratory, each one a masterpiece in itself, each one a distinct and valuable gain to science. Hartig was as little free from error as any great man; but even where he erred in detail, his lucid and thorough discussion invariably brought new light to his subject by that wonderful faculty of seeing beyond the "thing in itself." To him *Fomes annosus* or *Dasyscypha willkommii* were not merely new forms of fungi he happened to discover; to him they were living organisms in close relation to other living organisms. Biology and ecology in our modern sense were not terms used in Hartig's earlier days, but Hartig was both a true biologist and an accomplished ecologist.

In his "Wichtige Krankheiten der Waldbäume," his "Zersetzungerscheinungen des Holzes der Nadelholzbäume und der Eiche" and papers from the "Untersuchungen aus dem forstbotanischen Institut I, II, III" Robert Hartig has laid the foundations of modern Forest Pathology.

Numerous later papers and books, particularly his "Lehrbuch der Baumkrankheiten," later "Lehrbuch der Pflanzenkrankheiten" (translated into English, French and Russian) brought an almost overwhelming amount of knowledge on the subject. His work is synonymous with Forest Pathology. None of his contemporaries has ever approached his fertility in this line; no man since has brought any fundamentally new concepts into this branch of science.

Although undoubtedly the father of modern Forest Pathology and, therefore, one of the most important contributors to phytopathology in general, Robert Hartig stands out as one of the most ingenious investigators in other lines of pure and applied botany as well. His contributions to our understanding of the mechanics of sap movement, of the activity of the cambium, of the mechanics of annual increment in trees, of the formation of spring- and summerwood, of the rôle of reserve material in the life of the tree have become common knowledge to such an extent that they form part of every textbook on botany.

Another side of his astoundingly many-sided lifework was devoted to problems in forestry. It would be out of place here to go into detail. In Forestry Robert Hartig is given the same rank as his father and grandfather. In younger years he has also done remarkably exact work in Entomology, especially on forest insects.

Besides the books already mentioned, Robert Hartig has given us twelve separate publications and about one hundred and fifty papers printed in periodicals, particularly in Tubeuf's *Forstlich-Naturwissenschaftliche Zeitschrift*, in the *Botanische Zeitung* and in forestry periodicals.

His influence on younger men has been an unusually strong one. A teacher of uncommon qualities, ever ready with advice, kind-hearted, inspiring, a strong personality, he has shaped hundreds of young foresters and botanists from all parts of the world and has had the good fortune to see a rich harvest spring up from the seed he has sown. In the midst of the most active work he died on October 9, 1901.

Robert Hartig, the scientist and teacher, the indefatigable worker, has built his own monument in the world of thought; but another image, that of Robert Hartig as the prototype of manly character and genuinely human qualities, lives forever in those who have been fortunate enough to know him in person.

OFFICE OF INVESTIGATIONS IN FOREST PATHOLOGY
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THE LIFE HISTORY OF ASCOCHYTA ON SOME LEGUMINOUS PLANTS. II¹

R. E. STONE

WITH ONE FIGURE IN THE TEXT

In a previous publication, the life history of *Ascochyta pisi* Lib. and *Ascochyta lethalis* Ellis and Barth. was given in some detail.² It was then shown that *A. pisi* Lib. was connected with *Mycosphaerella pinodes* (Berk. and Blox.) Stone on the pea and also that the same fungus occurs on *Vicia sativa* and *Vicia villosa* and was capable of infecting *Lathyrus odoratus*. It was also shown that *A. lethalis* Ellis and Barth. was a part of the life cycle of *Mycosphaerella lethalis* Stone. Subsequent publications by other authors have borne out these conclusions at least in regard to *Ascochyta pisi* Lib.^{3, 4}

In September, 1912, while looking for material of *Mycosphaerella pinodes*, a small plot of *Lathyrus sativus* (grass pea) was found infected with an *Ascochyta* having somewhat the appearance of *Ascochyta pisi* except that the pycnidia were smaller as were also the spores which were frequently without a septum. Since the work on *Ascochyta pisi* was still being carried on, careful watch was kept of the plot in order, if possible, to secure a *Mycosphaerella* or other Ascomycete which might be associated with this imperfect form on the grass pea.

In a few weeks an examination of the plants showed a *Mycosphaerella* to be present in considerable quantity. Since the fungus differed in some respects from *Mycosphaerella pinodes*, cultures were made from it for the purpose of determining its life history and its relation to the similar fungus occurring on the garden pea and vetches.

IDENTITY OF THE FUNGUS ON LATHYRUS SATIVUS L.

In Saccardo, Sylloge Fungorum, two species of *Ascochyta* are given as occurring on species of *Lathyrus*. *A. lathyri* Trail on *Lathyrus silvestris* and *A. orobi* Sacc. on *Lathyrus (Orobis) vernus*, etc. but none is recorded on *Lathyrus sativus*.

¹ Contributions from the Botanical Laboratory, Ontario Agricultural College.

² Stone, R. E. Ann. Myc. 10: 564. 1912.

³ Melhus, J. E. Phytopathology 3: 51. 1913.

⁴ Vaughan, R. E. Phytopathology 3: 71. 1913.

The Ascochyta collected here differs very much from *A. orobi* Sacc.⁵ in having much smaller spores. *A. orobi* has spores 15 to 16 μ by 4.5 to 6 μ , while the one collected here has spores 8 to 12 μ by 2.5 to 3 μ often without septa. It agrees closely with *A. lathyri* Trail⁶ as far as spore measurements are concerned, but, when it occurs on leaves, it frequently causes distinct spots as well as lesions on the green stems and pods. It has been shown that *A. pisi* may infect *Lathyrus odoratus*,⁷ but the fungus cannot be considered a form of *A. pisi* for the reason that repeated attempts at infection of *Pisum sativum* have given negative results and also the behavior in culture as well as the perfect stage do not agree with the fungus on the garden pea.

The species of *Sphaerella* listed as occurring on the genus *Lathyrus* are:

Sphaerella nemorosa Sacc. et Speg., *S. nerviseda* Speg., *S. nerviseda* var. *microspora* Sacc., *S. melaena* (Fr.) Awd.,⁸ *S. lathyri* (A. Pot.) Sacc. et Trav.,⁹ and *S. pinodes* (Berk. et Blox.) Niesl.¹⁰

Sphaerella melaena (Fr.) Awd. as described by Ellis¹¹ has yellowish spores, a character absent from the fungus according to Schroeter¹² and Winter.¹³ *S. melaena* (Fr.) Awd. is not a true *Sphaerella* but belongs in the genus *Ascospora*, a genus characterized by a subiculum and one celled ascospores.

Sphaerella nerviseda Sacc. et Speg. is characterized by slender spores 15 to 20 μ by 2.5 to 3 μ , quite different from the one under consideration.

Sphaerella Lathyri (A. Pot.) Sacc. et Trav. has larger perithecia, larger asci, and larger ascospores than the one found here.

It can not be considered a form of *S. pinodes* as the spores are smaller, it behaves very differently in culture and does not infect *Pisum sativum*.

The fungus agrees fairly well with *S. Nemorosa* Sacc. et Speg., but the ascospore stage has been found so far only on dead and dry leaves, stems, and pods and is not directly responsible for the formation of leaf spots.

It agrees very closely with *Sphaerella nerviseda* var. *microspora* Sacc. in the size of the spores and their arrangement in the ascus, but the spores are a little wider as is also the ascus. *S. nerviseda* var. *microspora* is given as occurring on dead foliage of *Orobis vernus* and associated with a Septoria and *Phyllosticta orobella*.¹⁴ The fungus collected here occurs

⁵ Sacc. Syll. Fung. 3: 398.

⁶ Sacc. Syll. Fung. 10: 303.

⁷ Stone. Ann. Myc. 10: 579. 1912.

⁸ Sacc. Syll. Fung. 1: 504 and 513.

⁹ Sacc. Syll. Fung. 22: 128.

¹⁰ Stone, R. E. Ann. Myc. 10: 579. 1912.

¹¹ Ellis. North American Pyrenomycetes.

¹² Schroeter, Cohn. Kryptogamen flora.

¹³ Winter, Rabenhorst Kryptogamen flora.

¹⁴ Sacc. Syll. 9: 615.

on dead leaves, stems, and pods of *Lathyrus sativus* and is associated with an Ascochyta whose immature spore might well be taken for a Phyllosticta. The fungus occurring here is sufficiently different from the ones already described to warrant its consideration as a new species.

In proposing a name, one is somewhat at a loss to know just what generic name to use. If we consider Sphaerella as a *nomen conservandum* then it should be called Sphaerella.¹⁵ If we follow the usage of Schroeter,¹⁶ Lindau,¹⁷ Rehm, and others, the proper generic name would be Mycosphaerella, while, if we follow the suggestion of Wollenweber,¹⁸ the name Pycnosphaerella should be used, since the perfect stage is connected with Sphaerioidiaceae conidial stage.

Mycosphaerella is here used to agree with the author's previous use of the name.¹⁹

Mycosphaerella ontarioensis sp. nov.

Peritheciis 50 — 100 μ x 70 μ ; erumpentibus subsuperficialibus, globoso-papillatis; osteolo brevis et pertusis; asci oblongo-cylindracei, sessilis vel breviter stipitato, apice poroso, 45 — 50 μ x 12 — 14 μ ; Sporidiis hyalinis 10 — 12.5 μ x 5 — 6 μ , medio septatis, lenter constrictis, apice acutis, cellulae 2-guttulatis; oblique monostichis.

In foliis, caulibus et fructibus emortuis Lathyrī sativi. September — March, Guelph, Ontario. Socii spermagoniis Ascochyta.

Maculis epiphyllis, caulibus et fructibus, sordidis-brunneo, marginatis vel obscuris. Pycnidiis sparsis; lenticularibus, erumperitis 75 — 160 μ ; brunneis pseudo-parenchymatis; Sporulis copiosis, cylindricis 8 — 12.5 μ x 2.5 — 3 μ , mox 1, septatis non constrictis vel continuis.

In foliis, caulibus et fructibus, languidis et emortuis, Lathyrī sativi. June — October, Guelph, Ontario.

Type specimen and cotype material deposited in Herbarium of New York Botanical Garden.

Collections.

Ascochyta: Guelph, Ontario, September 15, 1912, October 20, 1912, July, August, 1913.

Mycosphaerella: Guelph, Ontario, October 20, 1912, November 1, 1912, September, 1913.

Part of the collection of September, 1913, was kept out doors and examined at intervals until March, 1914. Asci and ascospores could be found at any time and the spores were in a viable condition until March or later.

¹⁵ Sacc. Syll. 22: 128.

¹⁶ Schroeter, Cohn. Kryptogamen flora. Pilze.

¹⁷ Lindau, Engler und Prantl. Die Natürliche Pflanzenfamilien.

¹⁸ Wollenweber. Phytopathology 3: 229. 1913.

¹⁹ Stone. Ann. Myc. 10: 521. 1912.

It is probable that the specimens collected by Ellis at New Field, New Jersey, 1890, on the "Everlasting Pea" and labelled by him *Sphaerella melaena* (Fr.) Awd., and which was provisionally transferred to *Mycosphaerella pinodes*,²⁰ belong here as the characters of the asci and ascospores agree perfectly with the *M. ontarioensis*.

In working out the life history of *Mycosphaerella ontarioensis*, the same general plan was used as was employed in working with *M. pinodes* and *M. lethalis*.

CULTURES

October 21, 1912. Ten single ascospores were planted in bean decoction agar. Eight of these germinated and from each a colony of *Ascochyta* developed. The colonies were first visible in four days. At first they were white with a little aerial mycelium, but after ten days the colonies began to take on a brown color due to numerous chlamydospore-like cells. The chlamydospores were globose 15 to 20 μ in diameter with walls 2 to 3 μ thick and occurred in chains of 2 to 5. The chlamydospores were capable of germinating as shown in the figure. The colonies were slow to develop pycnidia, but after twenty-one days brown pycnidia containing typical pycnidiospores were formed.

November 6, 1913. Ten single ascospores were planted in nutrient bean agar. Seven of these germinated and gave rise to colonies as described in the first experiment.

January 8, 1914. Sixteen ascospores were planted in nutrient agar and of these thirteen germinated and gave rise to *Ascochyta* colonies with chlamydospores and pycnidia as previously described.

The presence of chlamydospores is a character which gives the colonies in culture much the appearance of *A. lethalis*,²¹ but the chlamydospores are much more numerous than in that species and the colonies are darker. In this respect they differ very much from *A. pisi*.

Ascospores were not obtained in cultures.

INFECTION EXPERIMENTS

Infection experiments were not tried in 1912 as there were no green plants obtainable which were suitable for the work.

November 26, 1913. Ten plants of *Lathyrus sativus* were sprayed with *Ascochyta* spores obtained from the cultures planted November 6, 1913. Eight of these plants developed typical lesions on the stems and leaves which bore pycnidia and spores. The pycnidia were mature on December 20, 1913.

²⁰ Stone, R. E. Ann. Myc. 10: 579. 1912.

²¹ Stone, loc. cit.

These same plants were allowed to grow under normal greenhouse conditions and finally the infected leaves and stems died and became dry. In February, 1914, these dead and dry leaves and stems began to bear perithecia which were typical of the *Mycosphaerella* from which the *Ascochyta* cultures were obtained.

January 26, 1914. Four plants were inoculated with *Ascochyta* material obtained from ascospores planted January 8, 1914. All of these

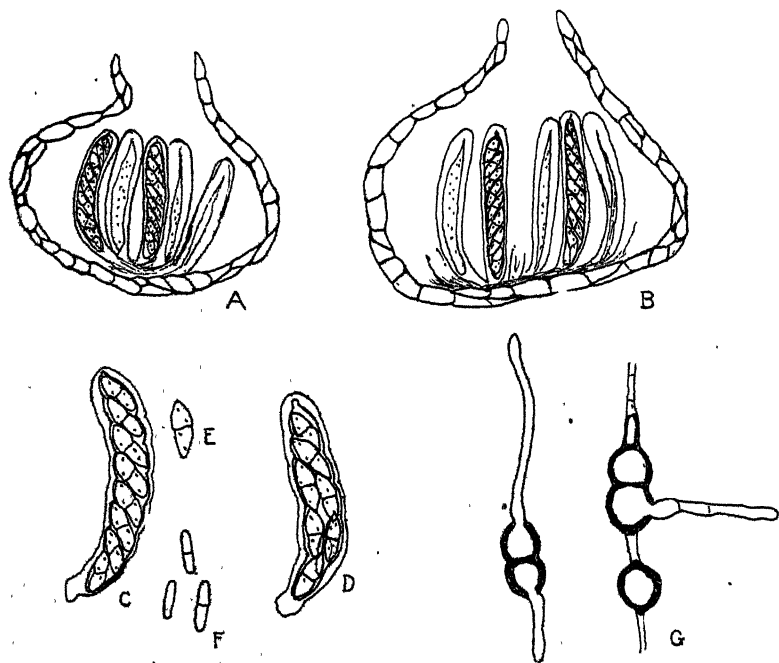


FIG. 1. A and B, longitudinal sections of typical perithecia of *Mycosphaerella ontarioensis*, $\times 350$; C, ascus of the same developed in a greenhouse, on plants inoculated with *Ascochyta*, $\times 500$; D, ascus of the same developed in the field, $\times 500$; E, a typical ascospore, $\times 500$; F, pycnidiospores, $\times 500$; G, chlamydospores developed in culture germinating, $\times 500$.

plants developed *Ascochyta* and by May 1, 1914, perithecia with typical ascospores were developed on the dry parts of the diseased plants.

March 1, 1914. Two plants were enclosed in moist chambers with old stems and pods bearing viable ascospores. These plants developed the typical *Ascochyta* and by May 15 dry stems and leaves were developing typical perithecia and asci of *Mycosphaerella ontarioensis*.

In all cases the check plants remained free from the disease.

CONCLUSIONS

The grass pea (*Lathyrus sativus* L.) in this locality acts as the hosts for an Ascochyta resembling *A. Lathyri*. Later the same plants bear an Ascomycete closely related to *Sphaerella nerviseda* var. *microspora* Sacc. which is here named *Mycosphaerella ontarioensis*. The *Mycosphaerella* and the Ascochyta are stages in the life history of the same organism.

1. The *Mycosphaerella* follows the Ascochyta in the field.
2. The ascospores when planted in nutrient agar give rise to an ascochyta which is capable of infecting the host plant.
3. The infected areas develop typical Ascochyta like the plants in the field, and later these same diseased areas develop a *Mycosphaerella* indistinguishable from the original material.
4. Plants inoculated with ascospores directly develop first the typical Ascochyta and later the *Mycosphaerella*.
5. In all cases the check plants remained free from the disease.

CONDITIONS FOR ASCOSPORE DEVELOPMENT IN MYCOSPHAERELLA PINODES AND MYCOSPHAERELLA ONTARIOENSIS

In many cases of ascomycetes which have a parasitic conidial stage, the imperfect form is found during the growing season on the living parts of the plants, while the perfect stage appearing the following spring is found on the dead leaves, twigs, fruits and so forth on the ground, i.e. *Venturia pomi*, *Mycosphaerella fragariae*, *Guignardia bidwellii*, etc.

It occasioned some surprise, therefore, when work was begun on *Mycosphaerella pinodes* to find the perfect stage as early as July and August of the same season and on the same material which had developed the conidial stage. Often the two stages were intermingled. The condition is the same whether *M. pinodes* occurs on the pea or vetch. The same conditions hold for *M. lethalis* on the sweet clover and *M. ontarioensis* on the grass pea.

In the previous work done on *M. pinodes*, the ascospore stage was not obtained²² but Vaughan²³ in his work states that in one experiment he obtained ascospores on his inoculated plants in the greenhouse. He gives no details of the work, however.

While the present work on *Mycosphaerella ontarioensis* was being carried on further, work on *M. pinodes* was carried along with it. As ascospores were developed with both fungi some idea of the conditions for their development was obtained.

²² Stone, loc. cit.

²³ Vaughan, R. E. *Phytopathology* 3: 71. 1913.

MYCOSPHAERELLA PINODES

February 10, 1913. Ten pea plants were inoculated with a pure culture of *Ascochyta* obtained from the ascospores. By March 3 the pycnidial stage had passed its prime and the plants were beginning to wither. By April 1, the plants were all dead, but they were watered as usual. May 21, perithecia with ascospores were mature.

November 14, 1913. A number of pea plants were similarly inoculated and the plants treated in a similar manner. By March 24, 1914, the ascospore stage had appeared.

In the first case the ascospore stage appeared in a little over 3 months from the time of inoculation and after a period of six weeks of purely saprophytic existence at the ordinary greenhouse temperature. In the other case four months elapsed, but the plants had remained green longer so that the saprophytic existence was for about the same length of time.

MYCOSPHAERELLA ONTARIOENSIS

By referring to the experiments previously cited in this paper we can see what is the rule for the present fungus.

Inoculation
November 20, 1913.
January 26, 1914
March 1, 1914.

Ascospores obtained
February, 1914.
April 27, 1914.
May 15, 1914

In these cases the time between inoculation and the formation of the perfect stage was two and one-half to three months. Here perithecia developed on dead and dry leaves still attached to green stems and on dead and dry stems themselves.

In these cases the plants were kept growing in an ordinary greenhouse along with the conservatory plants, etc.

If we examine conditions in the field, we will see that under normal conditions these fungi develop their imperfect and perfect stages under similar temperature and biological conditions. In fact the ascospores are most easily obtained in August and September after several days of dry weather. These fungi develop their perfect stage after a period of one or two months of saprophytic existence at a temperature of 60 to 70° F. or even higher.

It would seem from these instances that our idea that the Sphaeriales, having a parasitic conidial stage, require the variations of temperature and factors attendant on a winter season in order to develop their perfect stage, is not well founded. It would be worth while to experiment with other forms in order to throw more light on this little understood question.

ONTARIO AGRICULTURAL COLLEGE

THE TEMPERATURE RELATIONS OF SOME FUNGI CAUSING STORAGE ROTS

ADELINE AMES

This investigation was undertaken with a view of getting some exact data on the thermal relations of a few of the fungi causing storage rots. The growth of some of these fungi at lower temperatures has been investigated in a general way in refrigerating experiments, but the more detailed work has been limited to a few of the common saprophytes.

H. Hoffmann¹ in 1860, experimenting with several fungi among which were *Trichothecium roseum*, *Fusarium heterosporium*, *Penicillium glaucum* and *Botrytis vulgaris*, found that they germinated very near the freezing point and that they did not lose their vitality at a temperature below freezing, although such a temperature was fatal to germinating spores.

Wiesner² found the maximum and minimum temperatures for the germination of the spores of *Penicillium glaucum* to be 43°C. and 1.5°C., for the development of the mycelium 40°C. and 2.5°C. and for the formation of spores 40°C. and 3°C.

Tiraboschi³ found that *Penicillium glaucum* did not germinate at 37°C. and maintained at that temperature for a month completely lost its power of germination.⁴ Thiele working with the same species determined the maximum temperature for germination to be between 30° and 35°C. He experimented with several strains and found that the same species grown on different media or media of different concentration had a different maximum temperature. The discrepancies in the results of the temperature limits of *Penicillium glaucum* as determined by these different workers might have been due to incorrect identification of the species as well as to variation in physical or biological factors.

¹ Hoffman, Hermann. Untersuchungen über die Keimung der Pilzsporen. Jahrb. f. wissensch. Bot. (Pringsheim) 2: 267-297. 1860.

² Wiesner, Julius. Untersuchungen über den Einfluss der Temperatur auf die Entwicklung des *Penicillium glaucum*. Sitzber. K. Akad. Wiss. (Vienna) Math. Naturw. Kl. 68: 5-16. 1874.

³ Tiraboschi, C. Attenuazione del potere germinativo delle spore di *Penicillium glaucum* mantenuto a 37°C. Rivista pellagologica 8: 1-16. 1908. For abstract see Centralb. f. Bakt. Abt. 2. 22: 463. 1909.

⁴ Thiele, R. Temperaturgrenzen der Schimmelpilze. Leipziger Dissertation. 1896.

Istvánffy⁵ found that the spores of *Monilia*, *Botrytis*, and *Coniothyrium* did not germinate above 39°C. to 41°C. Exposure to freezing temperature for a week destroyed a large percentage of the spores. Spores kept dry for some months were more sensitive to cold than those from fresh cultures.

Ewert⁶ investigated the so-called summer or conidial stages of some of the ascomycetes which are supposed to be carried through the winter only in the perithecia. The conidia of *Mycosphaerella sentina* subjected alternately to artificial cold as low as -16°C. and thawing temperatures germinated as readily as untreated conidia. A small percentage of the conidia of *Pseudopeziza ribes* left over winter where the temperature went to -22°C. germinated in the spring. *Fusicladium pyrinum* and *F. dendriticum* were used to represent tests on hyphomycetous fungi. After several exposures to temperatures below freezing, they did not germinate as readily as untreated spores. The author concluded that resistance to cold did not depend on the protection afforded by the pycnidium but was due to qualities innate within the protoplasm.

Eustace⁷ among others, conducted some cold storage experiments on fruits inoculated with rot producing fungi. Apples were inoculated with *Penicillium*, *Glomerella rufomaculans*, *Sphaeropsis malorum*, and *Cephalothecium roseum* and placed in cold storage for two months. *Penicillium* produced a small rotted area at 1°C., but the other fungi grew only a small amount even at 8°C. At 26°C. the fruits inoculated with *Cephalothecium roseum* and *Alternaria* showed rotted spots, those with *Glomerella* were partially decayed and those with *Penicillium glaucum* entirely rotted. Peaches inoculated with *Monilia fructigena* after two weeks at 0°C. showed small rotted spots.

From the results of these different workers, the difficulties of eliminating all factors other than temperature are readily seen. The strain and peculiarities of the individual species of fungus, its previous habitat, its age, the conditions of moisture, the nutritive qualities of the media on which it is to be grown and the time factor in relation to temperature, all must be considered.

The fungi selected for this work were *Glomerella rufomaculans* (Berk.) Sp. & von Sch. and *Cephalothecium roseum* Corda from apples. *Thiela-*

⁵ Istvánffy, Gy. A Botrytis, Monilia és Coniothyrium sporáinak életképességéről matematikai és természettudománys estésatő. A. M. T. Akademia 3 osztá lyán ak folyóirata 21: 222-235. For abstract see über die Lebensfähigkeit der Botrytis, Monilia and Coniothyrium Sporen. Centralbl. f. Bakt. Abt. 2. 11: 584-586. 1904.

⁶ Ewert, Dr. Die Überwinterung von Sommerkonidien pathogener Ascomyceten und die Widerstandsfähigkeit derselben gegen Kälte. Zeitschr. f. Pflanzenkr. 22: 129-141. 1910.

⁷ Eustace, H. J. Investigations on some fruit diseases. N. Y. Agr. Exp. Sta. Bul. 297: 31-48. 1908.

viopsis paradoxa (de Seyn) Höhn. from pineapple, *Penicillium digitatum* (Fr.) Sacc. from orange, *Rhizopus nigricans* Ehrenb. from sweet potato and *Monilia fructigena* Pers. from plums. The strains used came from cultures isolated directly from the rotting hosts. String bean infusion (1 part by weight of beans to 2 parts of water), titrating plus 8 on the Fuller scale with $1\frac{1}{2}$ per cent agar-agar added was the medium selected for the stock cultures. All of the fungi grew luxuriantly on it. They were grown at what seemed to be their optimum temperature for growth, determined in a few preliminary experiments. Care was used in maintaining a constant temperature, as other workers have found that the temperature at which a mycelium develops influences the time required for the germination of its spores (Wiesner).

The experiment was divided into three parts: (1) The maximum and minimum temperatures for spore germination were determined and the time required for germination at different temperatures. (2) The amount of growth and fruiting at various temperatures. (3) The thermal death-point of spores exposed in a given solution to the heat of a water bath for a given period.

Germination tests. Dilutions in bean agar were made by transfers from slant bean agar cultures fruiting abundantly and not older than ten days. Van Tieghem cell drop cultures were employed and immediately after making were placed in the thermostats.

For the higher temperatures the cultures were grown in thermostats heated with gas burners and provided with a water jacket and a Roux thermo-regulator; for the lower temperatures the ice thermostat manufactured by Paul Altmann was used. It has compartments in which temperatures from 1°C. to 20°C. can be maintained. No thermostat for temperatures below 1°C. were available. Variations greater than 1° in an individual compartment were not experienced during fairly uniform weather temperatures.

The time at which germination began was noted. No attempt was made to determine the percentage of germination as no great difference was noted between the various cultures and the checks except in cultures at the extreme upper and lower limits of germination. The spores of most of the fungi germinated uniformly well. *Cephalothecium roseum*, however, showed great variability, often only a few spores out of several score in a drop would germinate. This could in no way be connected with its temperature relations but was rather due to a lack of vitality on the part of the fungus itself. Table 1 gives the time in hours required for germination.

Monilia and *Penicillium* only germinated at 1°C., but the spores of the other fungi, after remaining in the cool compartments several weeks with-

out germination, when brought to a higher temperature, germinated. Germination was much delayed, and the percentage of spores germinating was much smaller than when the culture was placed under favorable conditions.

Cultures left in the incubator thirty-six hours at a temperature a degree above the maximum temperature for germination did not germinate when removed to an optimum temperature. One or two spores in a few excep-

TABLE 1
Time in hours required for germination of the spores

TEMP.	THIELAVIOPSIS PARADOXA	RHIZOPUS NIGRICANS	MONILIA FRUCTIGENA	PENICILLIUM DIGITATUM	GLOMERELLA RUFOMACULANS	CEPHALOTHE- CIUM ROSEUM
<i>deg.</i>						
1	None	None	245	120	None	None
3-4	None*	200	144	90	200	None
5-6	168	168	100	48	174	None
9-10	45	51	24	32	39	96
10-12	23	43	7	15	15	24
15	13	36	7	8	8	15
17	8	16	7	8	7.5	9
19	8	16	7	8	7	7
20	8	16	7	8	7	7
25	8	13	7	8	7	7
28	8	12	7	8	7	7
30	8	10	7	8	7	7
32	7	8	7	8	7	7
33	7	8	7	None	7	7
35	6	6	7	2 spores out of many	7	7 (a few spores out many)
36	6	6	7		7	None killed
37.5	None	6	None		None	
38		5½				
39		5½				
41		5½				
42		None				
43		Killed				

tional cultures germinated but in most of the drops they seemed no longer viable. No systematic attempt was made to determine the period of heat rigor which the spores could endure and remain alive, although from the few general observations made it seemed much shorter than given by some workers for fungus spores. Helbrig³ for example found that some fungi were able to endure a long period of heat rigor. *Penicillium glaucum*

* Helbrig. Ueber den Einfluss supramaximaler Temperatur auf das Wachstum der Pflanzen. Leipziger Dissertation. 1900.

remained alive after an exposure of fifty-one days at one degree above the maximum temperature for germination.

The effect of the lower temperature was to retard germination, of the higher to destroy the cell. In a graphic representation of the period for germination in relation to the temperature, we would have a gradual downward movement of the curve until a temperature near the optimum is reached where it would remain nearly level to the maximum. In *Penicillium* a retardation due to the heat could be detected but in none of the other fungi. *Penicillium* spores germinated within eight hours at the optimum temperatures for growth. At 32°C. which is very near the maximum, a few of the spores germinated within eight hours and many after twenty-four hours. It may be that the spores germinating only after delay at the maximum temperature would not have germinated earlier if grown at an optimum temperature, although no such variation was observed in the tests made at this temperature. The spores of the remaining fungi germinated within as short a period at the maximum temperature as at the optimum and, at a degree above, would not germinate even if left for a longer period. No doubt if the incubators could have been regulated sufficiently accurately a point of delayed germination due to heat could have been located.

It was found that different strains of the same species sometimes have slightly different temperature limits. In the early part of the experiment a strain of *Monilia* obtained from peach was used. Its maximum temperature for germination was 30°C. The culture of this was lost and the work was repeated with a strain isolated from plums. The germination of the two strains at the lower temperatures approximately agreed, but the maximum temperature for growth of the second was 36°C.

Growth and fruiting experiments. In determining the amount of growth and fruiting at various temperatures one series of cultures was made on slant bean agar and placed immediately in the temperature compartments. Another series, made in Petri dish poured plates after germination at 25°C., was placed in the compartments.

Table 2 gives the data from the observations on these cultures. The fungi in general show the same temperature relations as in the germination experiments. *Monilia* and *Penicillium* are most resistant to cold and *Rhizopus* best adapted to higher temperatures. *Monilia* differed from the other species in that although the spores germinated at 35°C. no further growth occurred at that temperature and even at 30°C. the mycelial colony was limited in size.

Constant temperatures below 1°C. could not be maintained but that the fungi are not killed by lower temperatures was found in testing the viability of cultures left out of doors exposed to the winter temperature at

TABLE 3
Amount of growth at various temperatures

TEMPERATURE degrees	THELAVIOPSIS EXTREMITICUS	MONILIA FRUITIGEN ¹	RHIZOPUS NIGRICANS	GIOMERELLA RUFOMACULANS ²	CEPHALOTHECIUM ROBERTI M	PENICILLIUM GLAUCUM
1-2	No growth	No growth	No growth	No growth	No growth	Small colonies in a few cultures.
3-4	No growth	Small colonies. No fruiting	No growth	No growth	No growth	Small colonies.
9-10	No growth	Good growth. Fruiting within 8 days	Some growth. No mature sporangia after 1 month	Some growth. Conidia within 5 weeks	Small colonies. No fruiting within 1 month	No fruiting. Small colonies. Fruiting within 11 days
10-12	Small colonies. No fruiting within 3 weeks		Good growth. Mature sporangia within 3 weeks	Some growth. Conidia within 3 weeks	Small colonies. No fruiting within 1 month	Good growth. Fruiting within 4 days
14-16	Good growth. Fruiting within 3 days	Good growth. Fruiting within 3 days	Mature sporangia within 6 days	Good growth. Conidia within 8 days	Good growth. Fruiting within 6 days	Good growth. Fruiting within 3 days
17-18	Good growth. Fruiting within 2 days	Heavy growth. Fruiting within 2 days	Mature sporangia within 3 days	Good growth. Conidia within 6 days	Fruiting within 4 days	Heavy growth. Fruiting within 2 days
20-22 25	Good growth	M a x i m u m growth		Conidia within 4 days	M a x i m u m growth	Maximum growth
30	M a x i m u m growth	Scant growth. Abnormal mycelium and few conidia	Mature sporangia within 2 days	M a x i m u m growth	Small colony. Scant fruiting	Very small white colonies. No fruiting

	Good growth	No growth	Mature sporangia within 36 hours	Scant growth Scant growth. No fruiting No growth	Scant growth. No fruiting No growth	Small colonies of abnormal mycelium No growth
33						
35						
36	Scant growth. No fruiting		M a x i m u m growth	Scant growth. No fruiting		
37	No growth		Good growth	No growth		
40			Good growth			
42			No growth			

Ithaca, New York, where the thermometer registered -16°F. (-27°C.). Spores from these cultures (except *Cephalothecium roseum*) germinated as readily as those of cultures kept at room temperature.

It is seen, as generally conceded, that growth and germination occur at a temperature a few degrees below that at which fruiting takes place. Thus in *Thielaviopsis*, germination occurs at 5° to 6°C. but there is no fruiting although some growth at 10°C. Some of the *Glomerella* spores were able to germinate at 4°C. , but it required a temperature of 12°C. to produce normal spores. Similar differences are noted at the upper limits. Although *Penicillium* germinates at 30°C. and forms a small patch of mycelium, no conidia are produced. *Thielaviopsis* formed a mycelium at 36°C. but no conidia. The mycelium formed under the unfavorable conditions of the upper limits of temperature is not sufficiently vigorous to produce spores while at the lower limit the cold retards their development.

The cultures allowed to germinate at an optimum temperature and then placed in the cool compartments developed a mycelium at a lower temperature than those germinating in the compartments. Early growth under favorable conditions doubtlessly acted as a stimulus to a certain extent for the continuance of growth under unfavorable conditions. *Thielaviopsis* formed no mycelium at 9° , but cultures germinated outside formed a thin layer of mycelium even at a much lower temperature and microspores at 9°C. *Rhizopus* at 3° to 5°C. produced considerable mycelium although no growth beyond germination occurred in cultures placed immediately at this temperature. *Rhizopus* was very erratic in the production of sporangia. In one series of cultures, sporangia were formed at a temperature as low as 10° to 12°C. The tests were repeated some months later and no sporangia were obtained at 20°C. and even at higher temperatures in many of the cultures. The results on spore germination agreed in all the experiments. No reason could be ascertained for this peculiarity in fruiting.

Thermal death-point experiments. The apparatus used in determining the thermal death-points consisted of a water bath heated by a gas burner which was controlled by a thermo-regulator. The water was maintained at a uniform temperature through the motion created by a revolving water wheel. The temperature was read from a thermometer suspended in the water.

Transfers of the spore masses were first made to tubes of distilled water. After the tubes were well shaken to separate the spores in order to avoid discrepancies due to unequal heating, transfers were made from these tubes to tubes containing 10 cc. of bean decoction. They were then exposed in the water bath for ten minutes after which they were removed to an incubator set at 25°C. The figures given in table 3 indicate the lowest temperature at which there was no growth after such treatment or the thermal death point.

The results of the germination tests and thermal death points relative to one another are in accord. *Rhizopus*, which has spores germinating at a high temperature, has a high thermal death point and *Glomerella*, *Monilia* and *Thielaviopsis*, which have spores germinating at about the same temperature, have like thermal death points. *Penicillium* shows the greatest difference between the thermal death point and the maximum temperature. The *Penicillium* spores have a greater tendency to adhere in masses than those of the other species and it may be that the figure given is too high because the spores were not uniformly heated. As stated above, care was taken to avoid this, and the experiment was repeated several times but with like results.

The low thermal death point of *Cephalothecium* was probably due to the attenuation of the cultures. The thermal death points were determined toward the close of the work and for some time in all of the cultures *Cephalothecium* had shown a lack of vigor.

TABLE 3
Thermal death points

THIELAVIOPSIS PARADOX	RHIZOPUS NIGRICANS	MONILIA FRUITIGENA	PENICILLIUM DIGITATUM	GLOMERELLA RUFOMACULANS	CEPHALOTHE- CIUM ROSEUM
52.5-53°	60-60.5°	52-52.5°	58-58.5°	53-53.5°	47-48°

Summary. The cardinal points of temperatures are within the limits stated in general for fungi by other workers. *Monilia* and *Penicillium* germinate at 0°C. but growth is very slow. The other fungi do not develop below 5°C. but if growth is started at a higher temperature, it can continue at this temperature. Aside from *Rhizopus* none of the organisms is able to germinate above 36°C. The optimum temperature of growth for *Monilia* and *Penicillium* is 25°C., *Thielaviopsis*, *Glomerella*, and *Cephalothecium* 30°C., *Rhizopus* 36°C. The thermal death point of *Rhizopus* is 60°C., of *Penicillium* 58°C., and those of the remaining fungi between 51°C. and 53°C.

The results indicate that in refrigerating experiments, temperatures near zero must be maintained if development of rot producing fungi is to be entirely avoided. From the effect of the exposure to low temperatures on the germination of the spores, one can also conclude that the conidial forms of fungi are much more resistant to cold than is commonly supposed.

Acknowledgments are due to Dr. Erwin F. Smith for the use of the ice thermostat in his laboratory and to Misses McCulloch and Hedges for observations made on some of the cultures.

BUREAU OF PLANT INDUSTRY
U. S. DEPARTMENT OF AGRICULTURE

STORM AND DROUTH INJURY TO FOLIAGE OF ORNAMENTAL TREES

CARL HARTLEY AND THEODORE C. MERRILL

WITH THREE FIGURES IN THE TEXT

GENERAL

The season of 1913 was unusually dry and hot in many parts of the country. A number of severe local storms also occurred. In consequence of these conditions inquiries from correspondents had little to do with parasitic leaf trouble, but there was much complaining of injury which could not be definitely traced to parasites. Detailed observations were made in the District of Columbia, and places in Pennsylvania and New Jersey were also studied. In the District the rainfall from March 1 to May 26 was excessive. For June and July, the total rainfall was only 35 per cent of normal while the weather was at the same time very hot. This period was followed on July 30 by a hail storm, heavy rain, and wind of 68 to 70 miles per hour. In August and the first half of September there was little additional rain. Vineland, New Jersey, was without drouth and Montclair, New Jersey, was subjected to a severe drouth in June. The places mentioned furnished favorable opportunity for studying the results of different meteorological conditions.

DROUTH INJURY

In the District of Columbia at least 25 per cent of all Norway maples were noticeably affected. Those surrounded by impervious paving material suffered most. As might naturally be expected well rooted trees in parks and cemeteries resisted the short sharp drouth. Leaf injury was practically all marginal. A typical case of this type of injury is shown in figure 1. Marked cases showed dead tissue extending into the body of the leaf between the veins. Where injury was most serious, practically the entire leaf was killed, and the leaf dropped soon after this extensive damage. Most of the leaves less severely injured than the one figured persisted during the remainder of the season. In some instances a spotted leaf injury, probably due to drouth, affected areas lying in the interior of leaves, with only moderate marginal injury. Sugar maple also exhibited injury both marginal and between the veins, though the proportion of trees affected was much smaller than in the case of Norway. Distribution of

the injury was noticeably localized in many trees, certain branches being nearly defoliated, while others between them were nearly uninjured. This condition was especially marked in sugar maple and indicated considerable differences in the ability of different branches to compete for water. Injury to the leaves was unexpectedly uniform on all sides of the crown

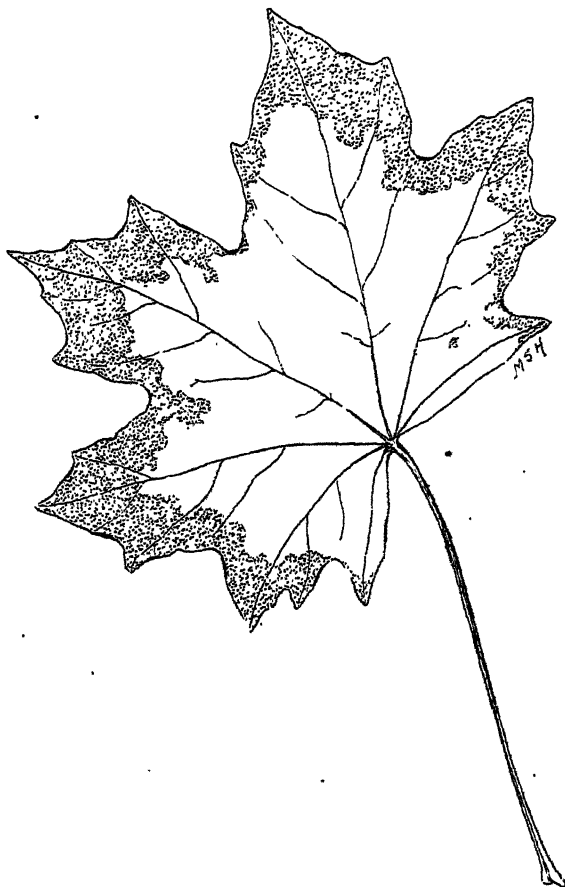


FIG. 1. Norway maple. Shaded area indicates part killed by drouth.

though it was oftenest more severe on the south and southwestern aspects. The age of street trees bore little relation to the amount of injury, Norway maples 2 inches and 10 inches trunk diameter (breast height) being about equally affected. Leaves on the extreme periphery of the crown, not shaded by others, were more injured than those in the interior. Silver maples suffered somewhat from drouth, injury being marginal. Sycamore

maples largely escaped, as did also two other exotic maples *A. palmatum* (Asia) and *A. campestre* (Europe), the two latter being found in parks rather than in street planting. Some American basswoods showed marginal injury. Elm dropped some of its leaves but those remaining were not materially damaged. Horse chestnut in some streets suffered heavily. Injury to leaves not entirely killed was mostly terminal or in fewer cases marginal. Most of the injured street trees were nearly defoliated.

An especially interesting case of drouth injury occurred on pin oak (*Quercus palustris*). During the latter part of August, a ditch 5 or 6 feet deep was opened alongside a row of pin oaks near the United States Treasury, passing within 4 feet of most of the trees, which were about 10 inches in diameter. This ditch cut a number of roots. One of the trees was not more than 2 feet from the ditch, which was allowed to remain open for some time, so that in addition to the cutting of part of the roots, water loss from the soil containing uninjured roots was increased by evaporation through the wall of the ditch. During the first week in September the foliage of several of these trees turned yellow, the greatest injury appearing in the one nearest the ditch. Damage developed rapidly so that the tree nearest the ditch was practically defoliated by the middle of September, when the ditch was filled and the trees were heavily watered. Leaves on this tree died at once all over the tree and fell within a few days after the first symptoms appeared. The few persistent leaves showed typical marginal injury, living leaf tissue remaining along the main veins only (fig. 2). With one exception all trees along this ditch showed marginal leaf injury and partial defoliation, while no trees in the row beyond the end of the ditch were affected. The defoliated tree retained the green cambium of the twigs and showed reasonably healthy buds at the time of the last examination a month later. The leaves of many pin oaks in other parts of the district were yellowish and unhealthy during the latter part of the summer, but only a few had their margins killed by the drouth.

Certain infrequent injury seen in Norway maples may have been parasitic. This injury appeared as unusually light-colored dead blotches or areas of $\frac{1}{4}$ to 1 square inch situated in the leaf interior. Often it was adjacent to the veins. A differential point between this kind of injury and the marginal drouth type is its general occurrence in leaves shaded by location within the crown, while drouth mostly damages leaves situated externally. In Philadelphia, where no serious drouth occurred, this type of injury was more frequent, affecting both Norway and sugar maples. At Vineland, New Jersey, where no serious drouth was reported, this "blotch" type of injury seemed to predominate on both Norway and sugar maple, and silver maple was not injured.

In Montclair, New Jersey, and vicinity the injury was confined mostly to sugar maples and was generally distributed through the crowns of a few trees. It showed no uniform preference for any particular point of the compass in affected trees but appeared mainly in the upper and outer foliage and was generally marginal. Weather reports and the character of the injury indicate drouth as the cause. In Montclair there is much



FIG. 2. Pin oak. Shaded area indicates part killed by drouth.

local interest in trees and considerable attention is devoted to their conservation. Plenty of watering and liberal planting space are provided and as a consequence the trees show the effect of the favorable environment.

Thuja occidentalis showed early browning of older foliage to an unusual extent, other white cedars suffering to a lesser degree. Numerous other species of conifers in the vicinity of Washington were not affected, though

growing close to the injured arbor-vitae, and under the same conditions. Among these were *Thuja orientalis*, *Chamaecyparis lawsoniana*, *Libocedrus decurrens*, *Juniperus virginiana*, *Taxus baccata*, *Taxodium distichum*, *Picea parryana*, *P. excelsa*, *P. orientalis*, *Tsuga canadensis*, *Pinus excelsa*, and *P. strobus*. All the specimens of *Taxodium* available for comparison were much larger and probably older than the arbor-vitae, which may explain their freedom from injury.

Reports by correspondents show drouth near Knoxville, Tennessee, as evidenced by wilting of leaves of black and white oak and dogwood. Weather Bureau records at Knoxville showed a more serious deficiency in rainfall than at Washington. A great many injured maple leaves on which no parasite could be developed were received from drouth-affected portions of New York and New England. Tip burning of white pine needles was reported from the northeastern states and especially from the Adirondacks. Premature browning of arbor-vitae was seen in Iowa specimens.

From the Holy Cross National Forest in Colorado, Forest Service officers reported damage to reproduction in lodgepole pines over considerable areas. Engelmann spruce and Alpine fir also suffered in the neighborhood of lodgepole stands. The growth of the current season was first injured in all cases. Many small lodgepole saplings were reported as entirely killed. Discoloration of the bark in dead parts of the tree varied from pale green to light brown and, at the base of the dead part, a line of very dark brown inner bark seemingly indicated a parasite, but observations made during previous seasons has shown that this browning of the bark at the base of dead twigs is not uncommon where young growth has been killed by non-parasitic factors. Cultures of such browned bark in moist chamber and on agar in the season of 1909 failed to develop any parasite. On September 4, 1913, similar specimens of injured lodgepoles were furnished by Mr. J. C. Blumer from Macdowell, Saskatchewan. It was stated that some of the injured trees presented an appearance as if fire had run through the tops. In western pines* this kind of tip killing shows death of entire twigs at once, whereas, in the sun-scorch type of the eastern white pine blight, death of the terminal parts of the needles commonly takes place before that of the lower parts of the twigs.

The effects on trees of a much more severe drouth than any encountered by the writers was reported from Nebraska by Pool,¹ who found early leaf fall especially prevalent with hackberry, elm, and Carolina poplar, while ash (*Fraxinus lanceolata*) was the least affected. As with defoliated trees at Washington, many completely defoliated trees put out a number of

* Pool, Raymond J. Some effects of the drought on vegetation. Science N. S. 38: 822-825. 1913.

new leaves near the end of the season, and abnormal autumn flowering was more common than at Washington. A number of street trees are reported to have died from the drouth during the summer, a result more serious than was observed in the vicinity of Washington. A more severe drouth than that at Washington is also reported for the summer of 1913 from southeastern Ireland.² In this case ash was among those that suffered most, showing a distinct wilting of the foliage even in middle aged trees, but no premature ripening as did other species of trees. Drouth was more easily observed in trees from four to eight years old, and Japanese larch in a six-years-old plantation suffered a large percentage of loss by death due to drouth. European larch and various spruces and pines in these young plantations suffered only to the extent of decreased growth. The drouths in Nebraska and most of the eastern United States, and in Ireland, during this season, were distinctly summer drouths of not over three months' duration, the spring rainfall having been above normal. A very brief drouth is evidently sufficient to cause injury to the leaves of the maples commonly used in street planting, detracting from their appearance but causing no permanent injury. That only street trees or trees recently planted were sufficiently injured to cause death in any of the cases above mentioned is to be expected from drouth of so short duration even with the maximum severity reported from southeastern Nebraska. If the spring had also been dry, injury to all sorts of shade trees might have been expected to follow in the places where summer drouth was most severe. However, the effect of the drouths noted on forest trees in general was so slight that we must expect extensive permanent injury or death of established trees only after successive seasons of severe drouth.

The writers are indebted to Prof. M. F. Ahearn, of the Kansas Agricultural College, for notes on the effects of successive drouths on ornamentals at Manhattan, Kansas. Here the season of 1912 had been dry, so that the soil was dry to an unusual depth at the beginning of 1913. 1913 drouth was very severe in this locality, and the cumulative water deficit resulted in the loss of well established trees of a number of species. *Pinus strobus*, *P. austriaca*, *P. sylvestris*, *Picea canadensis*, *Fraxinus lanceolata*, *Celtis occidentalis*, and *Aesculus glabra* were especially hurt. Arbor-vitae was seriously affected, and the Chinese arbor-vitae, commonly more drouth-resistant than the American, came out little better in this case. Norway maple was relatively uninjured, while red maple was seriously affected, contrary to the writers' experience at Washington.

The white pine blight in New England, on which considerable has been written within the last few years, seems largely due to recurrent drouths.

² Forbes, A. C. The effect of summer drouth upon tree growth. *Gardeners Chronicle*, Third series, 54: 299. 1913.

The most striking case of drouth injury recently noted,³ in which a large proportion of death of a dominant species occurred in high forest over considerable areas, was caused by two successive years of extreme drouth.

STORM INJURY

In the District of Columbia injury was noted particularly to sugar maple leaves in connection with the storm mentioned in the first paragraph. Trees showed storm effect on the northeast, from which direction the storm came. Injury was naturally greatest on the more exposed parts of the trees. In trees protected by buildings except as to the top or when the wind current was east to west in well built-up streets running east to west, injury was worse in the extreme tops and on the east, or even on the south-east sides. Blown-in windows on the south side of buildings showed that in certain places the full force of the northeast wind was deflected back toward the north by surrounding buildings. Trees in the suburbs growing under more natural conditions than those in the central part of the city were more exposed and showed correspondingly increased damage, instead of less damage, as in the case of drouth. Many sugar maples of all ages lost most of their leaf surface on the northeast side of the crown. Trees presenting the same exposure to the storm showed considerable differences in the resultant injury. These differences indicated a variable susceptibility or possibly an effect of soil conditions on susceptibility. Practically all exposed sugar maples were injured, most of them seriously enough to hurt their appearance for the remainder of the season, though no permanent effect is anticipated. The trees most exposed lost one-third or one-half of their leaves and a great number of the leaves on the northeast sides of the trees were so badly injured that they dropped within the next few weeks. Red and Norway maple and box elder suffered slightly from the storm, while silver maple was nowhere affected. A few basswood trees were injured very severely. Certain trees 10 to 14 inches in diameter lost all their foliage on the exposed side and in some instances most of the leaves on the opposite side were also killed. A few much-exposed horse chestnuts were also partly defoliated on the northeast side by the storm. Sycamore (mainly *Platanus orientalis*) and elm were generally uninjured. From tulip trees and ginkgos, in places of exceptional exposure, such as wind-swept corners, a large proportion of the leaves were torn away during the storm, but the remaining leaves were not harmed. Poplars suffered little damage. American beech, copper beech, *Paulownia imperialis*, and most other trees grown in parks were not seriously injured. The

³ Troup, R. S. A note on the causes and effects of the drought of 1907 and 1908 on the sal forests of the United Provinces. India Forest Department. Forest Bulletin 22, 17 p., pl. Calcutta. 1913.

native mixed hardwoods in forest and woodland areas escaped noticeable foliage injury, as was also the case with conifers.

Injury to maple leaves by storm presented unexpected resemblance to the injury by drouth. Nearly all of the leaves affected by storm, if examined without inspecting the trees, would have been considered in-



FIG. 3. Sugar maple. Shaded area indicates part killed by storm.

jured by drouth. Only inspection of the trees showing the injury mainly limited to the exposed side could afford a correct diagnosis. Observation was not begun soon enough after the storm to determine the exact appearance of the initial damage. Large areas of the leaves both at the margins and between veins were killed. The location of dead tissue on a typical leaf injured by storm is shown by the shaded portions of figure 3. The

injury to the lobes is most easily explained by the bruising and bending of the edges incident to the leaves whipping against each other and against twigs and branches in the high wind. The tissue between the veins, naturally more subject to bending than other parts, probably owed its injury to this excessive bending. While the hail must have helped accentuate this injury, it was difficult to find any injury which could be clearly attributed to hail alone. In most cases there was no evidence whatever of any laceration or even breaking of the epidermis until a long while after the storm, when the dead tissue had dried and shrunk away from the healthy part of the leaf. Definite creases with broken epidermis in the weaker tissues between the veins were caused by wind in many cases but this never resulted in the death of any considerable area of leaf tissue.

In addition to the typical storm injury, there occurred in Norway maples, and to a less extent in sugar maples, a peculiar injury which we have termed "maculate," involving very small polygonal dead spots scattered throughout the leaf without reference to margin or veins. Here also there was little or no breaking of the epidermis. While worst on the side of the tree most exposed to the storm, this maculate injury occurred more or less on all parts of the tree. It is thought that this injury may have been due to hail bruising, but there is nothing to prove this. Trees which had been previously injured by drouth seemed as free from this maculate injury as those which had not suffered from drouth. In no case was this injury of serious consequence as it did not cause the death of any leaves, and from a little distance simply dulled somewhat the normal color of the foliage. The killed areas were later somewhat increased in size, probably as a result of the work of weak parasitic fungi, which were able to spread by the start afforded them by the already killed tissue. Similar extension of non-parasitic spots in apple leaves has been previously observed by the senior writer in the case of inoculations with *Coniothyrium pirina*,⁴ and by Roberts,⁵ in work with *Alternaria*. Later in the season the leaf broke somewhat around the edges of the spots, the breaking being due to drying of the dead tissue and not to direct action of the storm. This type of injury was provisionally attributed to hail.

So far as could be observed the drouth preceding the storm was not a predisposing factor to storm injury, as trees which had previously shown drouth injury were not more damaged by the storm than trees which had not shown drouth injury, and street trees were less affected than those in open parks. It is presumed that most of the damage was caused by the breaking of cell walls in the leaf interior with consequent loss of water

⁴Hartley, Carl. Some apple leaf spot fungi. Science N. S. **38**: 157-9. 1909.

⁵Roberts, J. W. Experiments with apple leaf spot fungi. Journ. Agri. Research **2**: 57-65. 1914.

holding capacity. The main facts to be deduced from these observations are that sugar maple leaves proved very susceptible to injury by the high velocity storm, while Norway maple was especially susceptible to drouth injury. It does not necessarily follow that sugar maple would be so much more susceptible than other species to injury from all storms, irrespective of time of year or other variable factors; neither does it follow that Norway maples would be much more susceptible than the other species observed to a drouth occurring at some other time of year, or of a less severe but more protracted character. In nearly all the species affected by either drouth or storm the trees most severely injured put out a few leaves in September. On the horse chestnuts defoliated probably by drouth, and in other cases of early drouth defoliation, the leaves put out at the end of the season were very small. In the cases of storm defoliation, especially with basswood, the new leaves put out were noticeably large, and remained healthy long after frost had killed the older remaining leaves. In practically all cases, including the entirely defoliated pin oak near the Treasury, twigs and buds seemed fairly healthy after defoliation, and serious permanent damage to the trees is not expected.

In localities studied outside of the District, none showed material storm injury since there had been neither unusually high winds nor notable hail. Observations in Pennsylvania and New Jersey were useful chiefly in distinguishing between drouth effects and the supposedly parasitic blotch type.

In closing, it is especially interesting to note the resemblance of leaves injured by storm to those affected by drouth, particularly on sugar maple. Here the leaf is often unlacerated and gives little or no external evidence of mechanical injury. Damage as in drouth injury is chiefly marginal and between the veins. The only material difference seems to be that drouth injury is more closely confined to the leaf margins, while storm injury tends more conspicuously to affect areas situated between the veins as well. Inspection of the tree or knowledge of previous weather conditions, or both, seem necessary for positive differentiation between the two types.

OFFICE OF FOREST PATHOLOGY
BUREAU OF PLANT INDUSTRY

SOME OBSERVATIONS ON ORDINARY BEET SCAB

B. F. LUTMAN AND H. F. JOHNSON

WITH FOUR FIGURES IN THE TEXT

The identity of beet and potato scab, as far as the causal organism is concerned, was well established by Bolley¹ and Arthur and Golden.² Bolley found in North Dakota "a disease of beets identical with the deep scab of potatoes" and that out of fifteen fields producing scabby beets fourteen had been planted with potatoes the previous year. Arthur and Golden isolated, in Indiana, an organism from scabby beets identical with that obtained by Thaxter³ from scabby potatoes. They were further able to convey the potato scab to the beet by placing a piece of scabby potato against the side of a growing beet root.

A careful cultural study of eight organisms obtained from scabby beets from various parts of Vermont has convinced us of their identity with those already isolated in great numbers at this station from scabby potatoes and also, that all eight were the same organism (*Actinomyces chromogenus*). Minor differences in chemical and cultural behavior were observed but these were not greater than those obtained from separate isolations from the potato.

Some differences were observed, however, in the number of successful inoculations obtained on beets in the greenhouse in the five strains used. Only one of these would produce any number of scabs on injured beets, 18 per cent were successful with this organism, while with the other four, only occasional scabs would result, and these may have been due to other infections. Superficial injury to the beets led to about 50 per cent of successful inoculations with all five strains of the organisms. Deep injuries, such as those that might be made with a hoe, showed scabs in only a few cases after inoculation. It would seem, therefore, that there are differences in virulence in the various strains of organisms, and that a removal of the corky protective layer from the root is the best way to help the bacterium produce a scab.

The organism producing the ordinary scab on the beet and potato is undoubtedly identical, but the lesions it produces on the two hosts

¹ Bolley, H. L. Prevention of potato scab. N. D. Sta. Bul. 9. 1893.

² Arthur, J. C. and Golden, K. Diseases of the sugar-beet root. Ind. Sta. Bul. 39. 1892.

³ Thaxter, R. The potato scab. Conn. Sta. Rpt. 1890.

are quite dissimilar. The scabs on the potato arise frequently at the lenticels but may originate on other portions of the tuber,⁴ and the cork and cork cambium are the only tissues involved. The presence and growth of the organism on the outer layers of the cork brings about a stimulation of the cork cambium to produce cells, abnormal both as to size and number. The scab tissue is composed entirely of cork cells, although some investigators have claimed that some parenchyma occurs in some forms of potato scab (the bulging scab of Frank and Krüger).

Arthur and Golden noticed that the beet scabs were larger and more bulging than those of the potato, and that the brown outer portion of the scab could be wiped off, exposing the uncolored cork tissue beneath. Bolley simply states that the beet scab is formed at the ends of the pith rays in the region of the young roots. The inference is that the scabs are modified roots. He further observed that, while the deep scab of the potato is sunken, the similar disease on the beet bulges above the surrounding surface.

The growth of the beet root as followed by Droysen, quoted by de Bary,⁵ results from an external cambium. A new cambium is formed eight to ten times before the beet arrives at maturity, the regeneration proceeding each time from the outer cells of a layer of parenchymous tissue. Growth and cell division continue in this new layer for a time, but strands of wood and bast become differentiated in it and a new cambium is developed near the exterior of the root. This means that the cambium layer is placed as a result of this method of growth always at or near the surface.

The bacterium producing the disease seems to grow entirely superficially on the potato and beet, and it is probably only by the absorption of the toxic products that its stimulation is produced. Arthur and Golden noticed that the beet was often stained to a considerable depth due to the penetrations of the dark brown excretions of the organism. The beets used were presumably of a light colored variety, which showed this staining much more readily than the red fleshed garden varieties employed in the present work as the stain on the latter could not be observed beyond the first outer ring. It is by the absorption of these products, however, that the cambium is stimulated to form an abnormally large number of parenchyma cells, with a swollen mass of this sort of tissue as a result (fig. 1). The differentiation of these cells into wood and bast is also sometimes hindered by the toxic action of these substances and

⁴ Lutman, B. F. The pathological anatomy of potato scab. *Phytopathology* 3. 1913.

⁵ De Bary, A. Comparative anatomy of the phanerogams and ferns. Eng. trans. Oxford. 1884.

the ring of vessels is broken at the point immediately under the scab. The depth of this break depends upon the amount of growth after the infection has occurred, in most cases only a ring or two, but in large beets, nearly full grown, transplanted in the greenhouse and inoculated,

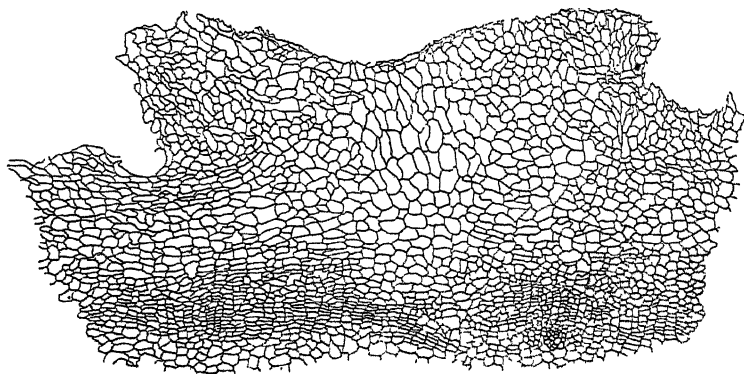


FIG. 1. Cross-section of a very young beet scab involving only the outer layer of the beet. Magnification about fifty diameters.

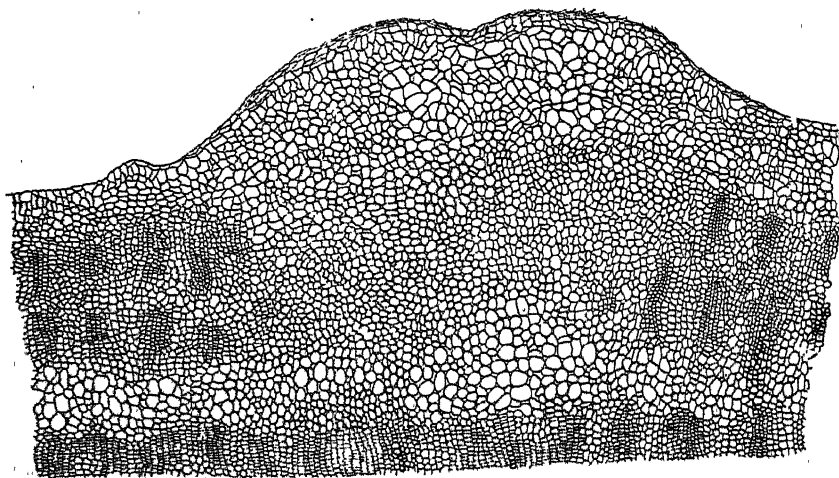


FIG. 2. Semi-diagrammatic cross-section of an old scab from a beet grown in the greenhouse showing three layers of the beet affected. These layers were very thin.

the interruption of three or four rings has been observed (fig. 2). The cells composing this spongy mass of parenchymous tissue are a little larger than these in the other parts of the root and toward the exterior are often lengthened in radially (fig. 3).

In the great majority of cases of beets grown in the garden, the protruding portion is due to an excess in growth of the rings directly under the infected spot and few if any of them are interrupted (fig. 3). The

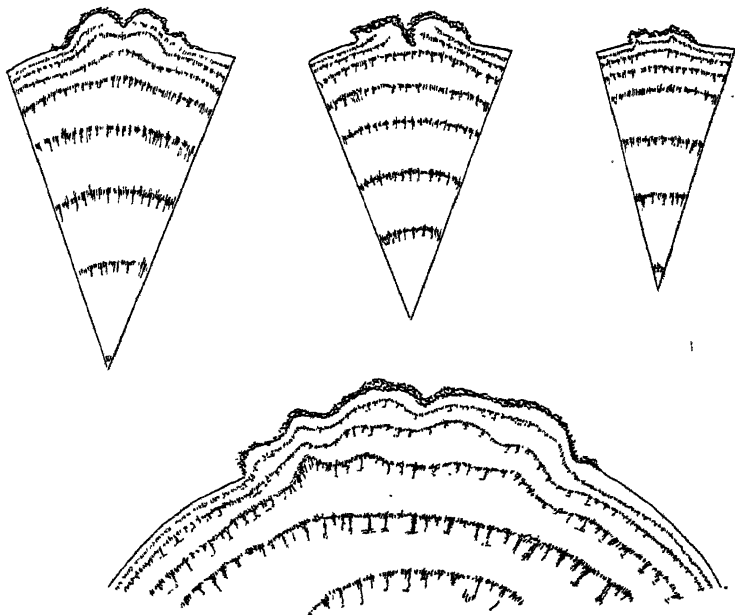


FIG. 3. Cross-section of beets grown in the garden. The rings of vessels have bowed out to form part of the scab tissue.

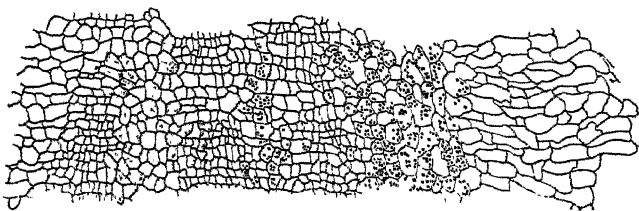


FIG. 4. Cross-section of a scab showing the numerous fat droplets present in the cells and the radial lengthening of the cork cells near the surface. Magnification about eighty diameters.

bulk of the tissue, however, is a soft parenchyma covered with a thickened layer of cork that may be readily wiped off, exposing the former cells.

The presence of spherical bodies in the cells under the scab tissue on the potato has been noted by a number of observers and was shown by one of the authors to be abnormal products of a fatty nature or at

least impregnated with fat. The cork cambium is free from them, but the cells of the outer layers of the starch parenchyma of the tuber contain great numbers. Their diversity in size and their staining reaction with osmic acid preclude the idea of bacteria and indicate that they are degeneration products in unhealthy cells.

Fixed and stained sections of beet scabs show similar bodies in the parenchyma cells lying between the rings. The larger spheres are found in the outer rings of parenchyma while those in the inner layers are often so small as to be barely distinguishable from the remaining portions of the cytoplasm (fig. 4).

The changes in the anatomical structure of the sugar beet, induced by similar organisms and described by Krüger⁶ as "girdle scab," result in a root, contracted by a ring of cork tissue around its upper portion. Krüger claims that the organisms isolated from these scabs are distinct from that producing the potato scab (and of course the beet scab with which it is identical) and has made distinct species of them although the cultural characters of some of them are not markedly different from those of the Thaxter organism. It is certain, however, that the morphological effects they bring about are decidedly more drastic.

The explanation of scabbing of the potato and beet, while many other root and tuber plants escape, undoubtedly lies in the fact that some sort of a cambium—either already present or easily regenerated—is so close to the surface that the toxic substances produced by these thread bacteria readily affect it. The same organism occurs in the greatest abundance in the soil and, as Beijerinck⁷ has shown, on the roots of many plants, but the anatomical structure of the underground portions of the majority of them is not of a nature to expose the cambium layers, through lenticels or otherwise, and they, therefore, escape scab formation even though covered externally by growths of the same organism. Its parasitism is dependent on a particular type of root or tuber structure and when this is not present it is forced to live as a saprophyte.

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⁶ Krüger, F.: Untersuchungen über den Gürtelschorf der Zuckerrüben. *Arb. Biol. Anst.* 4: 3, 1904.

⁷ Beijerinck, M. W.: Über Chinonbildung durch *Streptothrix chromogena*. *Centralbl. f. Bakt.* Abt. 2, 4: 2-12. 1910.

LONGEVITY OF PYCNOSPORES AND ASCOSPORES OF *ENDOTHIA PARASITICA* UNDER ARTIFICIAL CONDITIONS¹

F. D. HEALD AND R. A. STUDHALTER

• WITH PLATE II

INTRODUCTION

Both pycnospores and ascospores of the chestnut blight fungus are subjected in nature to a variety of conditions. The pycnospores after reaching maturity may be extruded in sufficient quantity to form spore-horns, or large numbers may be retained in the pycnidia during periods unfavorable for growth. During rain periods, spore-horns that are developed are soaked with water and the constituent spores dissipated, or the developing spores are washed down before accumulating in sufficient numbers to form visible spore-horns. These separated pycnospores lodge on the bark of the host or other nearby substrata, some are carried into the soil, and others are carried away by birds or insects, but sooner or later they will be subjected to drying. Ascospores are forcibly ejected and if they come in contact with moisture, germinate at once. Many expelled spores undoubtedly dry out before any opportunity is offered for germination. The effect of desiccation of pycnospores and ascospores of the chestnut blight fungus under different conditions is therefore one of the important phases of physiology bearing on the general problem of dissemination.

Pycnospores in the pycnidia, in spore-horns attached to the bark, or in separated spore-horns, are very resistant to desiccation as has been shown by Anderson (1). Later Anderson and Rankin (2) report that pycnospores in the spore-horn stage "showed very little diminution in the percentage of viable spores at the end of one year." The same writer states that "On the other hand, when the spore-horns were dissolved in water and the water allowed to evaporate leaving the spores in a separated condition on the slide, they did not retain their viability longer than a month." They give no results showing the actual percentage of spores viable after different periods of drying under these conditions. The work of Heald and

¹The writers wish to acknowledge valuable assistance from Mr. M. W. Gardner, who was associated with them during the earlier part of the work presented in these pages.

Gardner (3) has shown however that a certain percentage of the spores dried on soil retain their vitality for a much longer period than one month.

Ascospores retained in the perithecia in the bark are also very resistant to desiccation. Anderson and Rankin (2) report a large percentage capable of germination after eighteen months of drying. On the other hand, ascospores expelled from the perithecia and caught on glass slides are more sensitive to desiccation. According to Anderson (1) ascospores dried under these conditions failed to germinate after five months and six days. No work comparable to that in which separated pycnospores were dried on glass, has been reported for ascospores.

TABLE 1
Longevity of pycnospores of Endothia parasitica in water

NO. OF DAYS IN WATER	NO. OF VIABLE PYCNOSPORES PER CENTIMETER AT VARIOUS TEMPERATURES		
	42° F.	55° F.	75° F.
0	945,300	1,421,400	1,221,300
7	1,036,800	1,214,700	749,700
21	717,600	724,500	Contaminated*
28	882,000	874,800	
35	573,300	305,500	
42	487,500	455,100	
49	340,200		

* A series at a later date showed that there was no material differences at 75°F.

THE LONGEVITY OF PYCNOSPORES IN WATER

Since pycnospores do not germinate in water, the question of their longevity when immersed in water is of importance as shedding some light on the general problem of dissemination. If they survive long periods of immersion in water, dissemination by water currents following periods of heavy rainfall is a possibility that merits consideration.

In order to determine the longevity of pycnospores when immersed in water a single small spore-horn was placed in each of three flasks containing 100 cc. of sterile tap water, and the flasks were shaken to secure uniform suspensions. The number of pycnospores per cubic centimeter was determined at once by the poured plate method, and the flasks were stored at different temperatures. Determinations of the number of spores remaining viable were made at weekly intervals. The results are presented in table 1.

The successive tests showed a gradual reduction in the number of spores remaining viable, but at the end of forty-nine days approximately one-third were still capable of germinating.

A similar test was made later in which the spore suspension was kept in a cold room giving a freezing temperature. The reduction in the number of viable spores was less pronounced (table 2) than at the higher temperatures of the previous tests. From these tests it is apparent that pycnospores suffer but little in suspension in water.

TABLE 2
*Longevity of pycnospores of Endothia
parasitica in water at low
temperatures*

NO. OF DAYS IN WATER	RANGE OF TEMPERATURE SINCE LAST TEST DEGREES FAHRENHEIT	NO. OF SPORES PER CUBIC CENTIMETER
0	-32.0	55,993
1	-32.0	54,229
2	-32.0	55,245
4	26.5-31.0	57,190
6	22.5-30.5	56,875
10	23.0-31.0	56,515
13	25.0-33.0	54,927
16	27.0-34.0	58,102
27	23.5-33.5	57,303
36	26.5-41.0	50,947
41	29.5-42.0	50,566

THE EFFECT OF DESICCATION ON SEPARATED PYCNOSPORES

Our first work on the effect of drying on separated pycnospores was made by the hanging-drop method. This method did not give very satisfactory results but some of the work will be presented since it points to the character of the surface on which desiccation takes place as influencing the results. A stock suspension of pycnospores was made in tap-water on a glass slide, and small quantities transferred to tap-water, distilled water, rain water, and physiological salt solution, and dried on cover glasses and on cork plates. The original stock solution on glass was also allowed to dry and was tested the same as the others. The results are presented in table 3.

Although the tests show some irregularities to be charged to the method, they indicate that the conditions of desiccation on glass are more severe than on cork, a surface which is more comparable to the bark of the tree. The results also indicate that the concentration of the suspension diminishes the injurious results of desiccation, since there was a much higher percentage of germination from the original stock suspension than from any of the dilutions.

The following tests were made by the use of plate cultures and they yielded more reliable results. In this work a suspension of pycnospores was made by adding one or two small spore-horns to 100 cc. of sterile water. After obtaining a uniform suspension, 1 cc. was added to a second flask containing 100 cc. of sterile water. From this very dilute stock suspension of spores, one drop was added by a sterile 1 cc. pipette to each of a collection of sterile cover glasses. Plate cultures in 3 per cent dextrose agar were made from five drops immediately, five more were used as soon as dry, and a like number at intervals thereafter until no viable spores remained. The cover glasses carrying the dried suspensions were stored in sterile Petri dishes. Some preliminary tests showed that pycnospores dried on cover glasses did not readily wash off when the cover glass was flooded with the melted agar. To avoid error from this source, the cover glass to

TABLE 3

Effect of desiccation on viability of pycnospores determined by hanging-drop cultures

LIQUID USED FOR SUSPENSION	SURFACE ON WHICH SPORES WERE DRIED	GERMINATION PERCENTAGE			
		4 hours after dry	3 days after dry	7 days after dry	14 days after dry
Tap water	Glass	trace	0	trace	trace
Distilled water	Glass	0.50	trace	trace	0
Rain water	Glass	trace	trace	trace	1
Phys. salt solution	Glass	0	trace	trace	trace
Tap water	Cork	5.00	20-25	9.0	12.00
Distilled water	Cork	0.75	1.0	4.0	5.75
Rain water	Cork	2.00	2.5	6.0	6.00
Phys. salt solution	Cork	0.50	trace	6.5	2.50
Original stock in tap water	Glass	25.00	27.0	35.0	?

be tested was placed in the sterile Petri dish, the spore film covered with a few drops of sterile water and the film thoroughly rubbed up so as to separate the spores, before introducing the melted medium. The results of a test made by this method are given in table 4.

It may be noted from this test that immediately after drying only 30.2 per cent of the pycnospores remained viable. Two earlier tests made by the same method were questioned since it was determined that the pycnospores have a relatively low thermal death point (50° – 52° C.), and so might easily be killed by failure to sufficiently cool the medium used. One of these tests gave only 2.89 per cent of viable spores after 24 hours of drying, while the other showed no viable spores at the end of a similar period.

It has been suggested by Anderson and Rankin (2) that the gelatinous material covering the pycnospores serves as a protection in the drying process. This is in a measure substantiated by our results obtained by

TABLE 4

Effect of desiccation of pycnospores on glass determined by plate cultures

LENGTH OF DRYING	NO. OF COLONIES IN EACH PLATE					AVERAGE NO. OF COLONIES	PERCENT OF VIABLE SPORES
	1	2	3	4	5		
Control (not dried)	228	222	250	211	321	248.0	—
Just dry	93	81	81	73	52	75.0	30.20
24 hours	30	26	52	16	32	31.0	12.50
40 hours	36	35	46	33	16	33.0	13.90
3 days	—	26	31	26	30	28.0	11.20
4 days	13	17	42	34	21	25.0	10.00
5 days	—	9	17	9	34	17.0	6.80
10 days	0	0	0	1	0	0.2	0.04
20 days	0	0	0	0	0	0	0

the hanging-drop method (table 3). With this idea in mind a series of tests was made in which the pycnospores remained in suspension for varying lengths of time. The suspensions kept for 6.5 and 25 hours before making the cover-glass films were shaken frequently so as to insure as complete a solution of the mucilaginous coatings as possible. The same method was employed as outlined for table 4, and only a summary of the results will be offered (table 5). Although the spores in suspension for only 40 minutes showed the highest number viable immediately after drying, they showed no superior resistance to desiccation in the later tests. It is possible that there was sufficient washing in each series to dissolve the mucilage, but if this covering does protect the spores, the behavior is contrary to the results reported by Edgerton for the spores of the cotton anthracnose fungus. According to this writer (4) spores allowed to dry down in their mucilaginous matrix lost their ability to germi-

TABLE 5

Effect of washing on longevity of desiccated pycnospores

LENGTH OF DRYING	SERIES I IN SUSPENSION 40 MIN.		SERIES II IN SUSPENSION 6.5 HRS.		SERIES III IN SUSPENSION 25 HRS.	
	Average no. of colonies per plate	Percent of viable spores	Average no. of colonies per plate	Percent of viable spores	Average no. of colonies per plate	Percent of viable spores
Control (not dried)	5996.0	—	4640.0	—	7973.0	—
Just dry	2066.0	34.1000	1054.0	22.700	1833.0	23.6000
24 hours	35.0	0.5800	159.0	4.000	459.0	5.7000
3 days	50.0	0.8300	97.0	1.800	184.0	2.3000
7 days	5.2	0.0860	11.2	0.887	41.0	0.5140
14 days	0.2	0.0033	2.0	0.043	0.2	0.0025

nate in 20 days, while those from which the mucilaginous substance was removed by washing, germinated at the end of 30 days.

Field tests were planned in which suspensions of pycnospores were to be dried on living bark, leaves, etc., but only preliminary results have been obtained. It is worthy of note, however, that a pycnospore suspension dried on living bark in the open showed 42.58 per cent viable immediately after drying and 9.44 per cent viable at the end of 24 hours. Similar results were obtained from tests of pycnospores dried on living leaves. All of our work points to the fact that conditions of desiccation on a glass surface are more severe than on surfaces on which spores would be dried under natural conditions in the field. Tests made from spores dried on glass surfaces are then not a reliable index of the maximum longevity under field conditions.

THE EFFECT OF DESICCATION ON ASCOSPORES

It seems probable that the longevity of ascospores naturally expelled from the perithecia and collected on glass slides is not a reliable index of their persistence in nature. In this condition they are embedded in more or less gelatinous material expelled from the asci and are collected in more or less dense aggregates. Under natural conditions in the field, the expelled ascospores are separated and carried away by air or wind currents, and would dry as isolated spores, either before or after being washed by rains.

The effect of desiccation on separated ascospores was tested first by the hanging-drop method, dextrose agar being the medium used. A suspension of freshly expelled ascospores was made in tap-water and small portions were allowed to dry on glass and cork plates. The percentage of germination was obtained as soon as dry and at intervals thereafter. Under such conditions there was a drop from 70 per cent to 19 per cent germination as a result of drying for 24 hours; a second test of spores dried from distilled water gave a decrease from 53.4 per cent to 11 per cent after 24 hours. There was but slight difference between ascospores dried on glass and on the cork plates, but spores on the cork plates were more resistant to desiccation.

The plate culture method was also used for testing the longevity of desiccated ascospores. The technique was essentially the same as that described for the pycnospores, but the suspension was examined microscopically to determine the number of ascospores in a drop, and the number adjusted by additions or dilutions as was necessary. Freshly expelled ascospores collected on flamed slides were always used, and it was the aim to have each drop contain 500 to 1000. The results of a test by this method are recorded in table 6.

The results in this case show in a more striking manner than in the hanging-drop method, that separated ascospores are poorly equipped to withstand desiccation. With some irregularities there is a gradual decrease from 5.37 per cent of viable spores just after drying to 0.17 per cent at the end of 28 days. This rapid decrease in number of viable spores is well represented in plate II which shows a series of representative cultures taken from those on which the above table is based.

The length of time that ascospores are retained in water before drying may influence their resistance to desiccation. The longer period in water may more completely remove the mucilaginous coating, while germination processes will be initiated in a few hours. A comparison was made of two sets of desiccated ascospores, one being dried as soon as possible, the other after washing in water for 6 hours. The same method

TABLE 6

Effect of desiccation of separated ascospores on glass as determined by plate cultures

LENGTH OF DRYING	NO. OF COLONIES IN EACH PLATE					AVERAGE NO. OF COLONIES	PERCENT OF VIABLE SPORES
	1	2	3	4	5		
Control (not dried)....	563	525	622	644	568	584.4	
Just dry	54	29	26	29	19	31.4	5.37
24 hours....	7	15	10	17	41	18.0	3.08
2 days	18	17	13	41	19	21.6	3.69
3 days	10	9	2	0	4	5.0	0.86
4 days	4	30	6	11	16	13.4	2.29
5 days.....	0	4	3	6	2	3.0	0.51
10 days.....	2	6	4	30	3	9.0	1.54
18 days	3	3	0	0	4	2.0	0.34
28 days.....	3	0	0	0	0	1.0	0.17

was followed as recorded in table 6, and only a summary of the results will be presented (table 7).

Although some of the ascospores held in water for 6 hours remained viable as long as those washed for only 40 minutes, the reduction in the germination per cent of the washed ascospores was the more pronounced.

Some tests were made at Martic Forge, Pennsylvania, to determine whether ascospores dried on living bark and leaves in the fields were less susceptible to injury from desiccation than those dried on glass in the laboratory. Essentially the same method was used, the drops of water containing the ascospores being placed on marked areas and the sprouts used covered by a large tent fly during the night to protect them from possible rains. The test here reported (table 8) was a preliminary one and

TABLE 7

Effect of retention in water on longevity of desiccated ascospores

LENGTH OF DRYING	SERIES I. IN SUSPENSION 40 MINUTES		SERIES II. IN SUSPENSION 6 HOURS	
	Average no. of colonies per plate	Percent of viable spores	Average no. of colonies per plate	Percent of viable spores
Control (not dried).....	1130.0		1304.0	
Just dry.....	85.2	7.54	76.0	5.83
1 day.....	156.6	13.86	78.2	6.00
4 days.....	33.6	2.97	8.6	0.66
9 days.....	50.8	4.50	0	0
14 days.....	4.0	0.35	0	0
20 days.....	8.8	0.78	0.2	0.02
29 days.....	1.2	0.11	1.4	0.11
35 days.....	0	0	0	0

is not offered as conclusive, since more work is needed to substantiate the results.

The prolonged vitality of ascospores dried on living leaves and bark is in agreement with the results obtained in preliminary tests with pycnosporos. It seems probable that the greater vitality is due to a lesser degree of desiccation as some moisture would probably be supplied from the living cells with which the spores were in contact.

TABLE 8

Effect of desiccation of ascospores on living bark and leaves

LENGTH OF DRYING	DRIED ON LIVING BARK		DRIED ON LIVING LEAVES	
	Average no. of colonies per plate	Percent of viable spores	Average no. of colonies per plate	Percent of viable spores
Control (not dried).....	2700.0		3345.00	
Just dry.....	1187.2	43.97	707.25	21.14
1 day.....	629.4	23.31	352.00	10.52
4 days.....	503.4	18.64	488.00	14.59

SUMMARY

1. Pycnosporos retained in suspension in water at various temperatures show a very slow but gradual reduction in the number remaining viable. At temperatures from 42° to 75°F., one third were viable at the end of 49 days. At freezing temperature or below the loss of vitality was even less pronounced.

2. Pycnosporos when separated by water and allowed to dry are much less resistant than if dried in the form of spore-horns. A very large num-

ber of separated pycnospores, dried on glass, are killed in the process of drying, the per cent varying from 66 to 78, as determined by plate cultures. None remained viable for longer than two weeks.

3. Ascospores when separated and allowed to dry from suspension in water are much less resistant to desiccation than when dried in the form of spore prints on object slides. A very large number of separated ascospores dried on glass are killed in the process of drying, the per cent varying from 86 to 94, as determined by plate cultures. None remained viable for longer than 35 days.

4. Desiccation of spores on a glass surface gives more severe conditions than those usually found in nature. Both pycnospores and ascospores when separated and dried on living bark and leaves show a greater vitality than if dried on a glass surface.

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EXPLANATION OF PLATE II

Series of representative cultures from test recorded by table 6. Each plate represents the colonies developing from the ascospores in one drop of suspension after drying on cover glasses.

FIG. A. Control, not dried, 644 colonies.

FIG. B. Just dry, 54 colonies.

FIG. C. After 24 hours, 15 colonies.

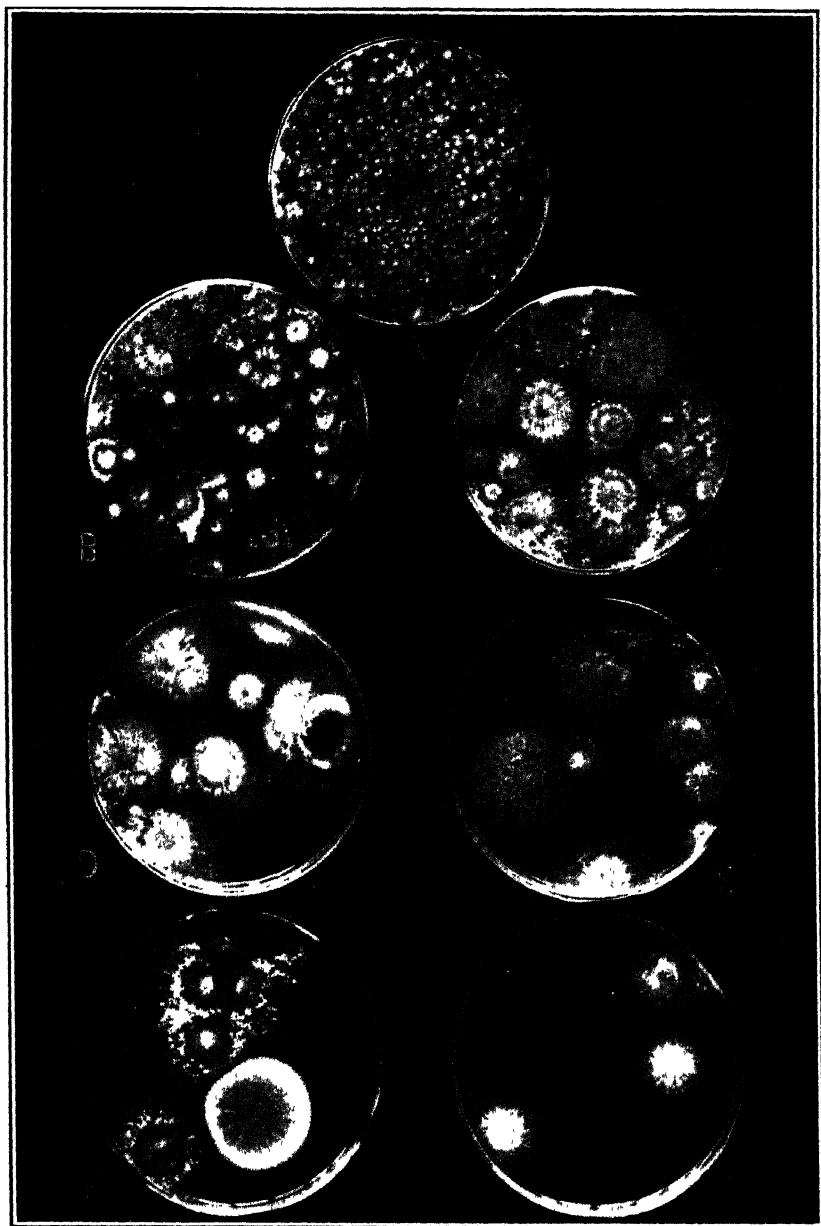
FIG. D. After 2 days, 13 colonies.

FIG. E. After 3 days, 9 colonies.

FIG. F. After 4 days, 6 colonies (1 foreign colony).

FIG. G. After 5 days, 4 colonies.

The experiment was started on May 14, the photograph taken on May 26.



HEALD AND STUDHALTER: *ENDOTHIA PARASITICA*

NOTES ON THE CHESTNUT BARK DISEASE

J. T. ROGERS AND G. FLIPPO GRAVATT

INOCULATIONS ON THE CHINQUAPIN

In Virginia the chinquapin in the vicinity of infections of the chestnut bark disease is very rarely diseased. However, the disease has been found on this species in several of the northern states and in one case in Virginia. As the chinquapin is very prevalent in Virginia, especially in the counties east of the chestnut zone, a definite test was made to determine its supposed resistance to the bark disease.

During July and August, 1913, 197 inoculations were made on 61 chinquapins in a patch near Leesburg, Virginia. Most of the chinquapins inoculated were rather small, though one tree measured 10 inches in circumference. The agar cultures used were made from material collected on the chestnut at Fontella, Virginia, and from material collected by Meyer on the Chinese chestnut in China. The inoculating material was inserted through small slits or holes made with a scalpel and these were not covered.

Of the 197 inoculations, 88 per cent gave positive results and the 30 checks remained uninfected. In a few cases the inoculations of July 21 had girdled the stems by October 6, 1913. The cankers resulting from inoculations made on August 16 and July 21 had developed a number of pycnidia with spore horns by October 6. It was thought that perithecia would be formed during the fall or winter, but an examination in March and again in August, 1914, failed to show any.

Three inoculations on chinquapin roots under soil gave positive results, but the growth of the fungus was very slight and the fans were not exactly typical. In March, 1914, on one of the small cankers there were several pycnidia.

From the growth records obtained at the March note-taking, there were indications that the culture of Chinese origin was slightly more virulent than the culture from Fontella, Virginia. Because of the smaller size of the chinquapins inoculated, at this time practically all of the cankers from the latter culture had completely girdled the stems. It was therefore not possible to secure definite data as to any difference in the virulence of the cultures. The average growth for the year, of the 5 cankers of Chinese origin inoculated August 16, 1913, which had not completed their girdle on August 15, 1914, was 6.8 inches.

These inoculations indicate that the chinquapin in Virginia has no more resistance to the girdling growth of the blight fungus than has the chestnut. However, the chinquapin does not have as many insect and other injuries as the chestnut, and this is the probable reason for its freedom from the disease in the field.

ONE YEAR'S SPREAD OF THE CHESTNUT BARK DISEASE OVER A SMALL AREA

Although several hundred articles on the chestnut bark disease have been published, no specific reference to the increase from year to year in a cankered or spore-producing area in a woodlot or of an individual infection has been made. To secure information on this particular point, a plot, 35 by 45 yards in dimension, was selected within the advancing edge of a large infection near Bluemont, Virginia. Most of the diseased trees, as would naturally be expected, were in the half of the plot nearest the center of the infection. There were in this plot 140 chestnut trees, which made up approximately 90 per cent of the stand. Most of these trees were of coppice growth and ranged from 1 to 19 inches in diameter, averaging about 4 inches.

On May 1, 1913, every chestnut tree in this plot was carefully examined and the cankers were measured and their edges marked with a lumber crayon. At this time 40 of the 140 trees were diseased, having a total of 58 cankers. Several of these cankers had already girdled the trees and therefore could grow only in a vertical direction. The total area of these 58 cankers was 20.79 square feet.

On September 1, 1913, counts and measurements were again made. Fifty-seven new cankers had developed since the first measurements. The total area of the cankers was 45.04 square feet, an increase of 116.6 per cent during the four months.

On May 1, 1914, final measurements were taken. The number of cankers had increased from 58 to 199, making 141 new ones, or a 243.1 per cent increase for the year. The total area of the cankers amounted to 95.80 square feet, an increase of 75.01 square feet, or 360.8 per cent during the year. The number of diseased trees increased during the year from 40 to 83. The growth of the blight in this particular plot was a fair average for the advancing edge of this particular infection. However, the percentage of chestnut, the density of the stand, the size and condition of the trees, and the temperature and moisture conditions, all are important factors which must be considered in determining the rate of spread. Variations in these factors make accurate comparisons between infections in different sections of the country difficult.

At the average rate of diameter growth of the disease cankers at Blue-mont, Virginia (6.35 inches for the year), it would require a number of years for a single canker to girdle a large tree. A number of cankers in this plot, which on examination at the end of the year appeared to have developed from a single infection, were actually made up of 3 or 4 separate cankers which had grown together. In this manner trees are girdled in a much shorter time than the rate of growth of single cankers would indicate.

SOME OBSERVATIONS ON ABORTIVE SPOROPHORES OF WOOD-DESTROYING FUNGI

JAMES R. WEIR

No satisfactory explanation has yet been given of the identity of the very peculiar, hard, brown, sterile, abortive fungus so common in some localities on birches. That this abnormality is a sterile form of some *Fomes* has long been recognized. It has been referred to *F. igniarius* (L.) Gillet, the usual *Fomes* on birches, or its variety, *F. nigricans* Fr. *Fomes everhartii* Ellis on *Quercus*, *F. rimosus* Berk. on *Robinia* and *F. pomaceus* Pers. on *Prunus* are somewhat similar to *F. igniarius*, but as noted are quite different in their host relations, neither are they known to produce sterile structures. Both the typical form of *F. igniarius* and its variety are occasionally observed on the same tree, but there is no record known to the writer of either occurring on the same trunk together with the characteristic sterile fruiting structure.

In Greenough Park at Missoula, Montana, numerous alder trees (*Alnus tenuifolia* Nutt.) are seriously infected by the typical *Fomes igniarius* making it necessary to remove some trees every year. The abortive fruiting bodies are likewise common; as high as three to five are occasionally formed on the stems of the same clump of trees. That there can be no doubt as to the identity of the sterile structures is shown by their relation and relative position with the typical fertile sporophores of *F. igniarius* on the same trees. The abnormalities are sometimes located just above, below, or occasionally between fertile fruiting bodies. A longitudinal section of the infected stem shows plainly that both the fertile and sterile fruiting structures originate from the same core of diseased wood, and indeed from the same mycelium. On clumps of the western birch (*Betula occidentalis* Hook.) springing from the same mother root, the characteristic abortive structure together with the typical *F. igniarius* is occasionally found. There is such a clump of infected birches in the park at Missoula, Montana. The writer has made collections of the abortive structures and the fertile sporophores of *F. igniarius* growing together on the paper birch (*Betula papyrifera* Marsh) in northern Michigan. The abortive sporophores, occurring generally on birches in the East, are exactly the same in appearance and structure as those found

on alder and birch in the West and must be considered abnormal forms of *F. igniarius*.

Practically in every case where two distinct wood-destroying fungi occupy the same substratum, the mycelium or the wood decayed by each is sharply outlined or bounded by infiltrated zones or thylose-like deposits in the cells. These zones or layers are similar to the lines of demarcation often appearing in the rot of a single species and which separates the diseased from the healthy wood. The antagonism of the mycelium of one species to that of another is a marked characteristic of many wood rotting fungi. *Trametes pini* seldom encroaches upon the wood of any conifer already occupied by *Echinodontium tinctorium* and vice versa. The rot of *Fomes pinicola* and that of *F. fomentarius* in the wood of the same birch tree is always sharply separated by a conspicuous black line although the decay produced by each species is quite characteristic. The same evident antagonism is often true in the case of purely saprophytic species when occupying the same substratum. The absence of any such lines of demarcation (other than those occasionally separating diseased and healthy wood) or evidence of antagonism between the mycelium in the rot of the typical *F. igniarius* and that of its most pronounced variety (*F. nigricans*) when occupying the heart wood of the same host, is an argument against the validity of the latter as a distinct species.

The abortive fruiting structures of *F. igniarius* practically in every case emerge from deep open wounds, usually a "cat face." The excellent photograph by von Schrenk and Spaulding (Bureau Plant Industry Bul. 149, fig. 2, pl. VI) shows this feature. The fertile sporophores, on the other hand, more often appear directly through the bark or at wounds where the vegetative mycelium is protected from external influences. At such points of emergence the context of the fruiting structure begins very early to form the hymenium which may be producing spores when the sporophore is not more than an inch in diameter. The collection of water in the deep open wounds, freezing and thawing, etc., has a tendency to maintain the mycelium at the point of exit in a constant vegetative condition; this and the probable oxidation of certain chemical substances within the wound due to exposure are probable causes for the formation of the peculiar abnormalities.

Abortive fruiting structures are occasionally formed by *Echinodontium tinctorium* on old and badly decayed western hemlock. The context of these structures is never materially different from the normal sporophore but the hymenium is entirely absent. Probably the most peculiar of all known abnormal structures produced by wood-destroying fungi outside the so-called genus *Ptychogaster* are those formed by *Trametes pini* on

the western white pine. They are usually found on old and badly diseased trees from which the normal sporophores have largely fallen. The mycelium at these old "punk knots" under some later stimulus produces most peculiar ram's-horn-like projections which are often six to eight inches in length. These bodies are usually mixed with pitch and show definite annual ridges of growth.

OFFICE OF INVESTIGATIONS IN FOREST PATHOLOGY

BUREAU OF PLANT INDUSTRY

MISSOULA, MONTANA

A BACTERIAL DISEASE OF CULTIVATED MUSHROOMS

A. G. TOLAAS

WITH PLATE III

In the mushroom caves in and around St. Paul, an unsightly spot on mushrooms is very prevalent. The severity of the spotting varies considerably on the different cultivated varieties, those most badly affected being the large white varieties. Very often the spots first appear when the mushrooms are in the early button stage, while in other instances they do not appear before the fruiting body has attained a considerable size. Only small areas may be discolored, or the entire cap and even the gills may be involved. At first the spots are pale yellow in color, but they finally become a rich chocolate brown.

The discoloration does not extend far into the fruiting body, the most severe cases observed showing the brown color but 3 or 4 mm. below the surface. The area in the immediate vicinity of this dark discoloration is usually yellowish white in appearance, but in cases where the attack is not so severe, the flesh remains perfectly white. The disease reduces crop yield but little, but the value of spotted mushrooms is, nevertheless, considerably diminished.

Microscopic examination and poured plates, as well as tissue cultures, show that bacteria are constantly associated with the disease. The organism most constantly present has proved to be the only pathogenic form.

Pure cultures were made by placing a piece of diseased tissue on a beef agar slant. In from 36 to 48 hours a greyish-green growth developed. From this, plates were poured, and the inoculation cultures were obtained from individual colonies in these plates. Inoculations were made with a platinum loop, care being taken not to injure the surface of the fruiting body. Numerous checks were kept. Successful infection was repeatedly obtained, the tissue along the line of inoculation becoming distinctly brown. The check plants remained healthy in all cases.

The causal organism is a facultative anaerobe of the *Pseudomonas* type, rounded at both ends, appearing slightly oval in shape with one or two polar flagella. When stained directly from a tissue culture it varies from $1.0\ \mu$ to $1.5\ \mu$ in length and measures $0.5\ \mu$ in width. When grown on beef agar or in beef bouillon, it increases somewhat in size, some of the

bacteria from these media measuring as much as $2.5\ \mu$ long and $1.0\ \mu$ wide.

The organism is easily stained by the ordinary basic anilin stains, carbol fuchsin giving the clearest result. It is gram negative and has been found to be actively motile in hanging drops made from 24-hours-old broth cultures. Endospores are not produced, a fact shown by staining and by the heat test.

Cultural characteristics were studied on the common media. A shiny greyish-white growth accompanied by a greenish pigmentation of the medium is produced on beef and potato agar. On potato cylinders a white glistening growth which changes to a creamy white is obtained. Nutrient bouillon is clouded within 36 hours. A ring or pellicle, very thick in some cases, is then formed together with increased clouding. There is a slight production of indol. No gas is produced in glycerine, nitrate, dextrose, lactose, or sucrose broths. Acid is produced in dextrose broth but not in the others. There is no diastatic action.

Liquefaction of beef gelatine begins in 48 to 96 hours. It is at first saccate, but the medium is completely liquefied in upwards of three weeks. Litmus-milk is coagulated in from 48 to 72 hours, the color of the whey being blue. Digestion is evident soon after and is usually complete in 15 days. Reduction of the litmus takes place until no color remains except a greenish tinge which is also characteristic when the organism is grown in beef agar and beef gelatine. When grown in beef bouillon to which methylene blue is added, the color is changed to a yellowish green. Nitrates are reduced.

The organism therefore takes the group number 221.2333133. This corresponds to the group number of *B. fluorescens* except for the fact that in dextrose broth the reaction is acid instead of alkaline.

A somewhat similar bacterial disease of mushrooms cultivated in the vicinity of Paris has been described by Costantin.¹ He ascribed the name la Goutte. This name is explained by the appearance on both cap and stem, during the first stages of the disease, of globules of a colorless grey liquid of variable size. Some time after the mushrooms have been picked, brown to greenish-brown spots appear where the globules have dried, forming a clammy surface.

L. Matruchot,² in studying the disease described by Costantin, mentions a peculiar viscosity of the cap at the place of the stains. This he ascribes

¹ Costantin, M. Julian. La goutte, maladie du champignon de couche. Extrait des Comptes rendus des seances de la Société de Biologie. (Séance du 5 Mars, 1892.)

² Matruchot, M. L. Des maladies du champignon de couche la goutte. La Culture des Champignon Comestible No. 24. June, 1909.

to what he calls active perspiration of the mushrooms, small drops of colorless or yellowish-grey liquid exuding, in time darkening and eventually producing the characteristic brown discolorations. .

I have not noticed any viscosity of the affected mushrooms or globules of colored liquid as described by Costantin and Matruchot. This fact is probably due to the comparatively dry conditions in the caves where the disease was studied. It is rather difficult to maintain a desirable humidity in these caves during the winter months since artificial heating is necessary for the production of the crop. This, together with a continuous draught, which is rather difficult to control under the existing conditions, has a tendency to lower the humidity. Hence the liquid exuding from the cap of the mushroom evaporates so rapidly as to prevent the presence of droplets as noted by Costantin and Matruchot.

Several experiments with a view toward devising means for controlling the disease were tried. Spraying the mushrooms with solutions of copper-sulphate, sodium carbonate, and benetol of various strengths did not seem to have any effect whatever in controlling the disease. Fumigating the beds with sulphur before planting the spawn was tried in one experiment and a crop of absolutely clean mushrooms was produced. The owner of the caves where the work was carried on now fumigates all of his caves, using about one and one-half pounds of sulphur per thousand cubic feet of space, and, as a result, the number of spotted mushrooms appearing is very small. This treatment costs about five cents per thousand cubic feet and has proved to be practicable.

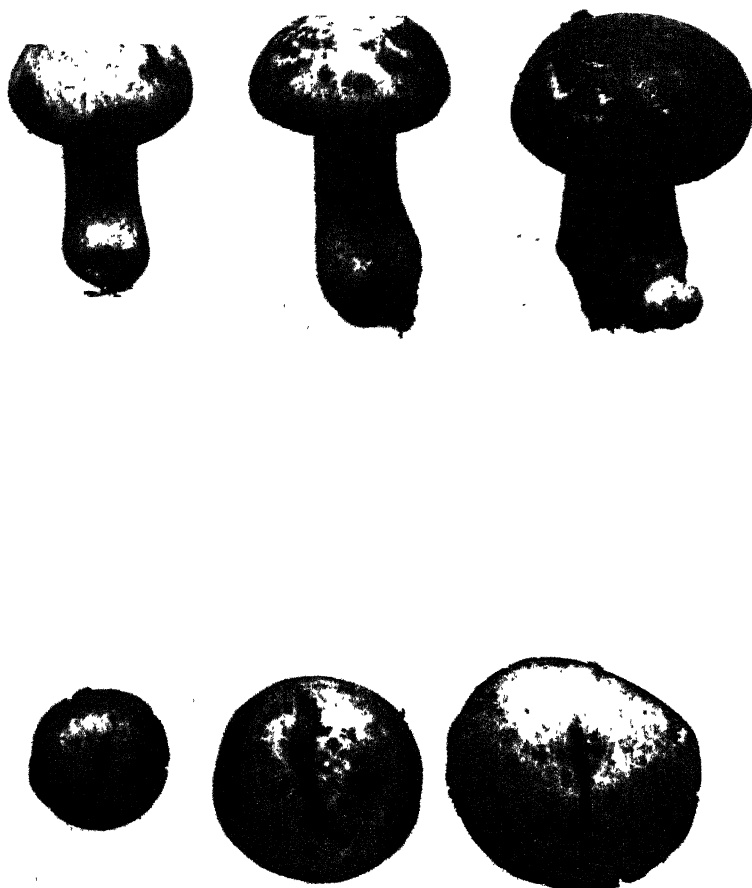
SECTION OF PLANT PATHOLOGY

COLLEGE OF AGRICULTURE

UNIVERSITY OF MINNESOTA

EXPLANATION OF PLATE III

- FIG. 1 Three mushrooms showing different stages in the progress of the disease.
FIG. 2 Mushrooms inoculated with pure cultures showing discoloration produced.



TOLAAS: A BACTERIAL DISEASE OF CULTIVATED MUSHROOMS

NOTES UPON WASHINGTON FUNGI

JOHN G. HALL

WITH PLATES IV AND V

THE ASCOSPORIC STAGE OF CORYNEUM

In the spring of 1913, I received, for identification, an ascomycete growing upon apple twigs. The specimens were sent to me from the Okanogan country of British Columbia by William N. Brittain to whom I am indebted for the two photographs and the description of the disease upon the apple. He wrote at the time of sending the material that it followed *Coryneum foliicolum*.

The disease attacks the young twigs and often completely encircles them. This causes the leaves to dry, curl, and become brown giving them very much the appearance of the "Fire Blight" (fig. 1). The fungus occurs more abundantly upon the apple trees growing in low, poorly drained clay lands along the valley roads. It is becoming a very serious pest in that region. Specimens collected upon the first of July, 1913, showed that the disease had ceased to be active for the season, and, that in many cases, the large cankers were nearly healed over.

In the cankers formed by the *Coryneum*, and taking the place of the *Coryneum*, are found the perithecia of the ascomycete. These perithecia rupture the epidermis of the bark in a longitudinal slit or a three pointed star (fig. 2). When these places are examined with a hand lens, one is able to see that the perithecia are entirely separate from each other but may be very closely packed against each other in some of the cankers.

From the ascomycete (which I have called *Otthia*) I made cultures with the hope that I might be able to connect that with the *Coryneum* occurring earlier in the season in the same cankers. Single ascospores (fig. 4) freed from the ascus (fig. 3) were taken from drops of sterile water in which a perithecium had been crushed after being washed in formalin. These spores were taken by means of a sterile capillary pipette and deposited upon poured agar plates. These spores were watched very carefully, the plate being examined several times during every day. At the end of twenty-four hours, it was found that some of the ascospores, after becoming considerably enlarged, were beginning to germinate (fig. 5). Some of these were then transferred to drop cultures in order that they might be more readily examined. The growth of the mycelium was very

slow at first (figs. 5 and 6). After the mycelium was well started, it grew rather rapidly until the sporodochia began to appear at the end of the fourth day. The young spores are at first formed at the ends of short sporophores arising from short lateral branches of the ordinary mycelial hyphae (fig. 7). Later these form a sort of stroma, the beginning of one of which is seen in figure 9. The spores are, at first, single celled but later form two transverse walls across them, thus making them three celled (fig. 8). At this time they were brown and looked so much like the *Coryneum* spores that they were at once compared with the *Coryneum* spores (fig. 10) taken from the cankers. In every point they were so nearly alike that they were considered the same fungus.

In the spring of 1914, while out collecting, I discovered the same ascomycete (*Othia*) occurring with what I took to be the same *Coryneum* upon *Sambucus* in the neighborhood of Pullman, Washington. I again made cultures from the ascomycete. The same precautions were taken with the isolations as in the previous case, and single germinated ascospores were transferred to poured plates of pea agar. The pea agar was made by boiling 40 grams of dry peas in a litre of water for half an hour. This was then filtered and 15 grams of agar added to the filtered solution.

Young spores soon appeared agreeing in every way with those grown from the apple disease. These spores were mature at the end of nine days, and they also agreed in size and septation with the mature spores in the cultures from the apple disease.

Examination of the *Coryneum* spores found upon the *Sambucus* showed them to be both two and three septate, but the two septate spores were very much more numerous than the three septate. A number of spores was counted and it was found that the proportion of two septate spores to three septate spores was 100 : 1. This proportion held good for five thousand spores counted.

Cultures were also made from the *Coryneum* spores found upon the *Sambucus*, and spores occurring in these cultures were compared with those grown from the *Othia*. They were found to be in every way identical. They were also identical with those of the *Coryneum* from the *Sambucus* and the Apple.

From these studies it seems to me that there can be no doubt that the fungi occurring upon the two hosts, Apple and *Sambucus*, are identical.

In making studies of the *Coryneum* stage of the fungus, I became somewhat doubtful about its being *C. foliicolum* and, after comparing it with specimens in the herbarium, I believed it to be, from all appearances, *Coryneum negundinis* Ell. and Ev. In order to be certain of this, I sent specimens of the fungus occurring upon *Sambucus* to Dr. Roland Thaxter of Harvard University for confirmation. He wrote back that the fungus

was not *Coryneum* at all but *Hendersonia diploidoides* Ell. and Ev., but that, in the older stages of the fungus, it might be very well taken for a *Coryneum*. On this account I suppose that we will have to call the *Otthia* the ascosporic stage of *Hendersonia diploidoides* Ell. and Ev.

After a study of the descriptions of all the *Otthias* with two celled spores, this *Otthia* seems to agree fairly well in all respects with *Otthia amica* Sacc. With the possible exception that the spores are a little longer than those of the last named species, they are identical and, as the measurements overlap, I believe that I am safe in calling the fungus *Otthia amica*. The spores of this *Otthia* measure $26.6-41.8 \times 11.4-16.2\mu$ while those of *Otthia amica* measure $22-30 \times 11-15\mu$.

TWO NEW SPECIES OF WASHINGTON FUNGI

The first of these fungi belongs to the group Sphaeropsidales of the Fungi Imperfecti. Upon study of the fungus, it was found to belong to the genus *Neottiospora* and I propose the following name:

Neottiospora yuccaeafolia n. sp.

Pycnidiiis fere hemisphaericis; ostiolo in plan plano latere posito, in folii contextum immerso, $216-324\mu$; sporulis fere cylindricis, hyalinis, granulosis, 1-4 cilia ad apicem gerentibus, $38-49.4 \times 7.6-11.4\mu$; ciliis $30-35\mu$ longis.

Hab.:—In foliis Yuccae depereuntibus aut mortuis. Pullman, Wash.

Pycnidia hemisphaerical with the mouth upon the flat side, immersed in the tissue of the leaf, $216-324\mu$ in diameter. Spores nearly cylindrical, hyaline, with 1-4 cilia at the apex, $38-49.4 \times 7.6-11.4\mu$ (fig. 11); cilia $30-38\mu$ in length.

The second of these fungi belongs to the hyphomycetes in the same group as *Goniosporium* and *Arthrimum*, but, since these are separated upon the shape of the conidia, I believe that it is necessary to make a new genus of this and on that account propose the following name:

Tureenia juncoidea n. sp.

Hyphis fertilibus, erectis, simplicibus, septatis, hyalinis, anulos ad septa fuscis gerentibus, basidio bulboso; sporulis ex sporophorae internodiis orientibus, fuscis, nariculariis, appendicula tenuia ad utrumque partem extremum emittentibus; $7.6-9.5 \times 15.2-19\mu$ (appendiculis omissis); appendiculis $7.6-11.4\mu$ longis.

Hab.:—In culmis Junci mortuis. Pullman, Wash.

Fertile hyphae erect, unbranched, hyaline with black rings at the septa, and with a bulbous base (fig. 12); spores borne upon the side of the internodes of the sporophore, dark colored, naviculate with slender appendages

at each end, $7.6-9.5 \times 15.2-19\mu$ without appendages; appendages $7.6-11.4\mu$ long.

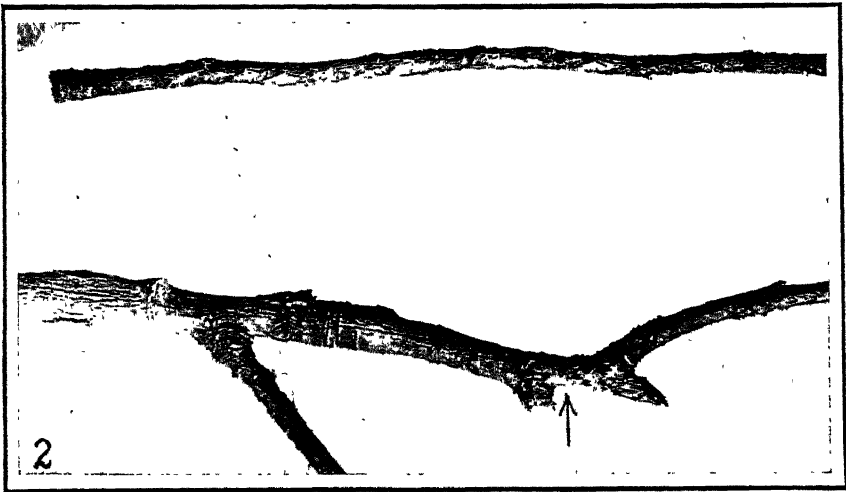
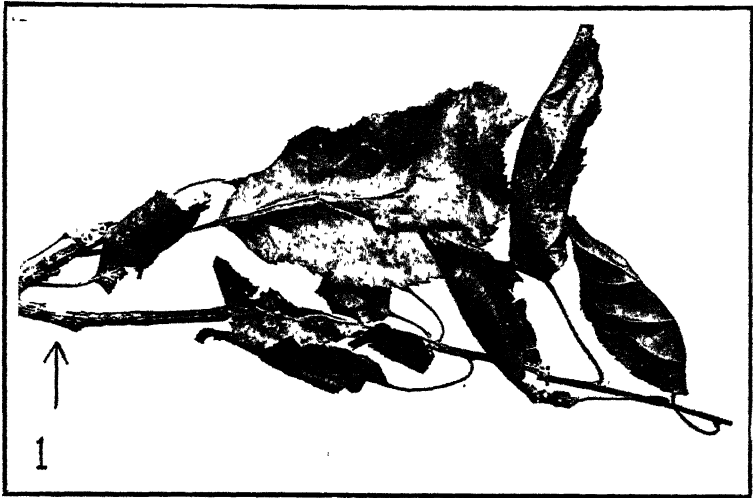
Specimens of these two fungi will be deposited in the cryptogamic herbarium of Harvard University, the New York Botanical Garden, and the Department of Agriculture at Washington, D. C.

WASHINGTON STATE COLLEGE

EXPLANATION OF PLATE IV

FIG. 1. Twig of Apple showing "Fire-Blight" appearance due to disease.

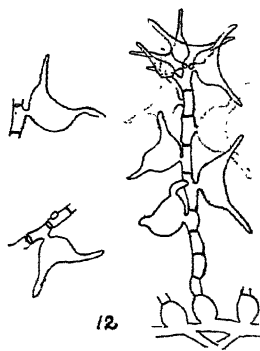
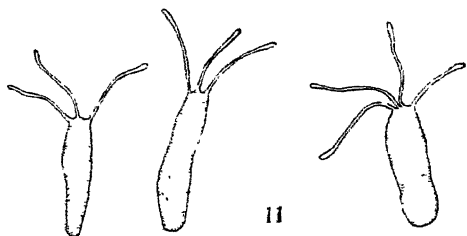
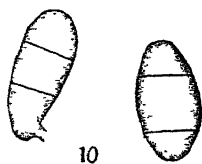
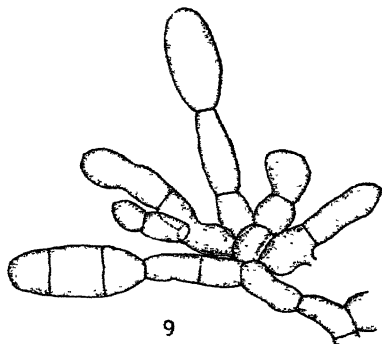
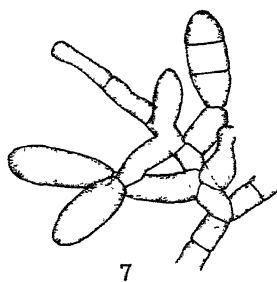
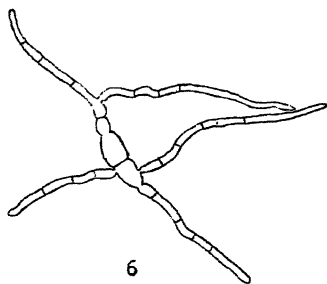
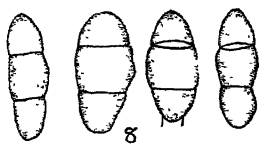
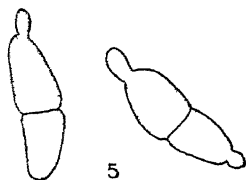
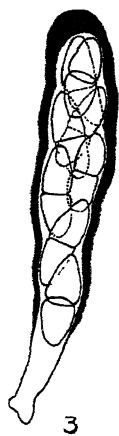
FIG. 2. Twig of Apple showing epidermis of bark broken by the perithecia. In both figures the arrows indicate the points of attack.



HALL: NOTES UPON WASHINGTON FUNGI

EXPLANATION OF PLATE V

- FIG. 3. Ascus of *Otthia* showing arrangement of spores.
FIG. 4. Ascospores free from the ascus.
FIGS. 5, 6. Germinating ascospores.
FIG. 7. Young spores from culture.
FIG. 8. Mature spores from culture.
FIG. 9. Spores and sporophores from culture showing the beginning of Sporodochia.
FIG. 10. Spores of *Coryneum* from apple twig.
FIG. 11. Spores of *Neottiospora yuccaeafolia*.
FIG. 12. Fertile hypha of *Tureenia juncoidea*, with two single spores.



THE RHIZOCTONIA LESIONS ON POTATO STEMS

F. L. DRAYTON

WITH PLATE VI AND ONE FIGURE IN THE TEXT

Investigators of the Rhizoctonia disease of potatoes, caused by the fungus now referred to as *Corticium vagum* var. *solani* Burt, have referred to the dark brown lesions occurring on the underground main stems and on the tuber-bearing stolons as the most prominent and typical symptoms of the disease. These lesions are irregular in shape, varying in size from the head of a pin to an area of some few centimeters in extent, sunken, dark brown and usually running longitudinally on the stem, but sometimes completely girdling the thinner portions. This injury is so constantly associated with other evidences of Rhizoctonia that it was taken for granted to be due to the parasitic growth of the Rhizoctonia mycelium; but apart from the fact of its association, and the presence of superficial hyphae, I failed to discover any further proof in any of the literature at my disposal.

In the more important investigations, the following statements may be found in connection with stem lesions.¹

B. M. Duggar and F. C. Stewart in 1901: "The hyphae occur in scab ulcers, those near the surface are brown, while the deeper lying ones are colorless." . . . "While the Rhizoctonia hyphae may be abundant in scab ulcers, there is no evidence that they have anything to do with the formation of the ulcers."

F. M. Rolfs in 1902: "The wounds below ground are usually characterized by a reddish brown color and vary in size and shape." . . . "On examining diseased plants, the parts below ground are thoroughly infected with *Rhizoctonia* and often the pith of the stem is filled with the fungus."

A. D. Selby in 1903: "The stems below the soil surface showed numerous lesions in the form of brown, dead areas. Microscopic study of the fresh material revealed the apparently constant presence of the hyphae of the fungus *Rhizoctonia*. The lesions are of diverse appearance, commonly having a darker character than the whitened portion of the stem beneath the earth. In advanced stages of the trouble, an oblong "blaze" more than an inch in length may be found along the side of the potato stem."

G. P. Clinton in 1904: "*The mycelium grows out on the young stems and roots. Sometimes it produces diseased or girdled areas.*"

¹ In all of these quotations the italics are mine.

G. H. Pethybridge in 1911: "Under certain circumstances, it may prove harmful; the tips of the young developing sprouts may be killed off by the fungus."

W. A. Orton in 1911: "*It may cause lesions on the potato stem at the soil line and below.*"

J. G. Hall and F. L. Stevens in 1913: "The black spots appear near the surface of the ground, destroying the bark and often girdling the stem. A dark network of fungus threads is sometimes seen upon the subterranean parts. On examining diseased parts, the injury caused by the fungus will frequently be found as a wound, often 2-3 cms. in length, upon the stem at or near the surface of the ground."

W. O. Gloyer in 1913: "The fungus may live as a parasite attacking the stems, stolons or roots of the plants. *At the point of attack, cankers are formed, which in time may increase so as to girdle the plant or separate portions from the main stem.*"

F. A. Sirrine in 1914: "This fungus attacks the young sprouts of the seed piece causing the brown cankers on them which frequently kill the sprout."

W. J. Morse and M. Shapovalov in 1914: "The lesions are brown in color and more or less covered with coarse brownish threads, apparently *Rhizoctonia*" "Brown lesions of various sizes began to appear on the sprouts below ground soon after they started from the seed pieces." "The brown diseased area may occur anywhere on the part of the stem below ground and extend from the surface inwards."

Later on in their bulletin, page 205, they express their opinion as follows, and this is the most important reference in this connection. "The lesions were dry in nature, and in the more advanced stages, brownish black in color and more or less covered with *Rhizoctonia* filaments. The fungus appeared to be entirely superficial. As far as could be judged by microscopical examinations, it did not penetrate beneath the skin to any extent. Occasionally discoloured streaks following the line of the vascular bundles penetrated the flesh for a short distance, but no trace of fungus mycelium could be found in them."

During the past summer, a great many hills of potatoes in our experimental field plots have shown symptoms of *Rhizoctonia* injury and particularly the dark brown lesions on the stems below ground (pl. VI, fig. 4) resembling in every respect those described in the above quotations. It was then that I was instructed by Mr. H. T. Güssow, Dominion Botanist, to carefully investigate these lesions microscopically to determine definitely whether, and if so to what extent they were really produced by the mycelium of the *Rhizoctonia* or whether they were merely lesions of independent origin erroneously associated with other well-known symp-

toms, such as the inward curling of the leaves, the production of sclerotia on the tubers, stems and roots, the failure of diseased hills to produce normal sized potatoes, and the occasional formation of aerial tubers.

The method of procedure adopted in this investigation and the results obtained are as follows: The material was collected during the month of August and a number of lesions of different shapes and sizes were chosen, some of which appeared as longitudinal local lesions, and others almost girdled the small tuber-bearing stems. Short pieces containing diseased areas were cut out, parallel to the surface, parings were made of the lesions on the bigger stems, and some were split in half and cut into short lengths. All of these pieces were fixed in Flemming's solution for six hours, washed thoroughly, dehydrated and embedded in paraffin of melting point 60°C., using chloroform as solvent. Sections varying in thickness from 6 to 10 μ , were then cut of this material with a rotary microtome in varying directions, transversely and longitudinally in each piece. They were then fixed on slides, stained with carbol fuchsin, and mounted in Canada balsam in the usual way.

RESULTS

The transverse sections of the parings showed the first indication of internal mycelium. These parings had been cut to the depth of the vascular bundles, and in every case a large number of cells in the cortex, varying from 3 to 6 cells deep from the surface of the lesion, were filled with granular, closely compacted hyphae, which were undoubtedly *Rhizoctonia* sclerotia-forming hyphae, as shown by the very characteristic short "bloated" cells with constrictions at the cell walls. Surface sections of the parings revealed the same condition, illustrated by a photomicrograph (pl. VI, fig. 1). Further sectioning of the whole and halved stems then revealed the actual penetration of the mycelium (fig. 5). Cells of the cortex, vascular bundles (fig. 2), and pith all were found to be invaded by mycelium, which from transverse and longitudinal sections proved to be that of *Rhizoctonia*. In the vascular bundles and pith, the compacted masses of hyphae which were found in the cortex were not observed, but, instead, individual hyphae were found running longitudinally and sometimes obliquely in the cells of these tissues and in the intercellular spaces.

As will be seen, the mycelial masses in the cortical cells resemble closely the structure of the so-called *Rhizoctonia* sclerotia, and they no doubt give the brown color to the lesions, and may well be a means of infecting subsequent crops in the same field if left on or in the ground in the same way that the sclerotia formed on the roots (fig. 3) are a means of reinfecting subsequent crops. This would emphasize the advisability of carefully collecting and burning all plant refuse after harvest, especially when the field was badly diseased.

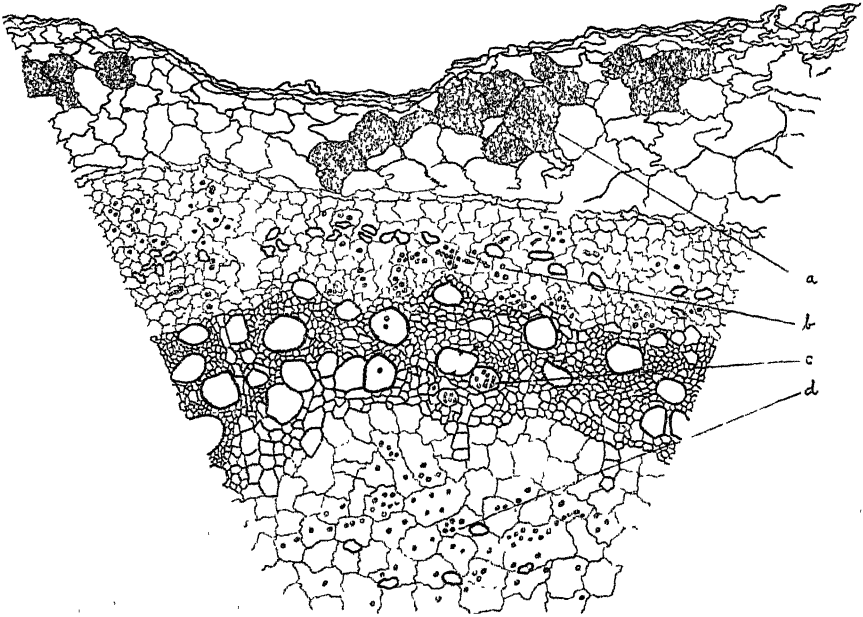


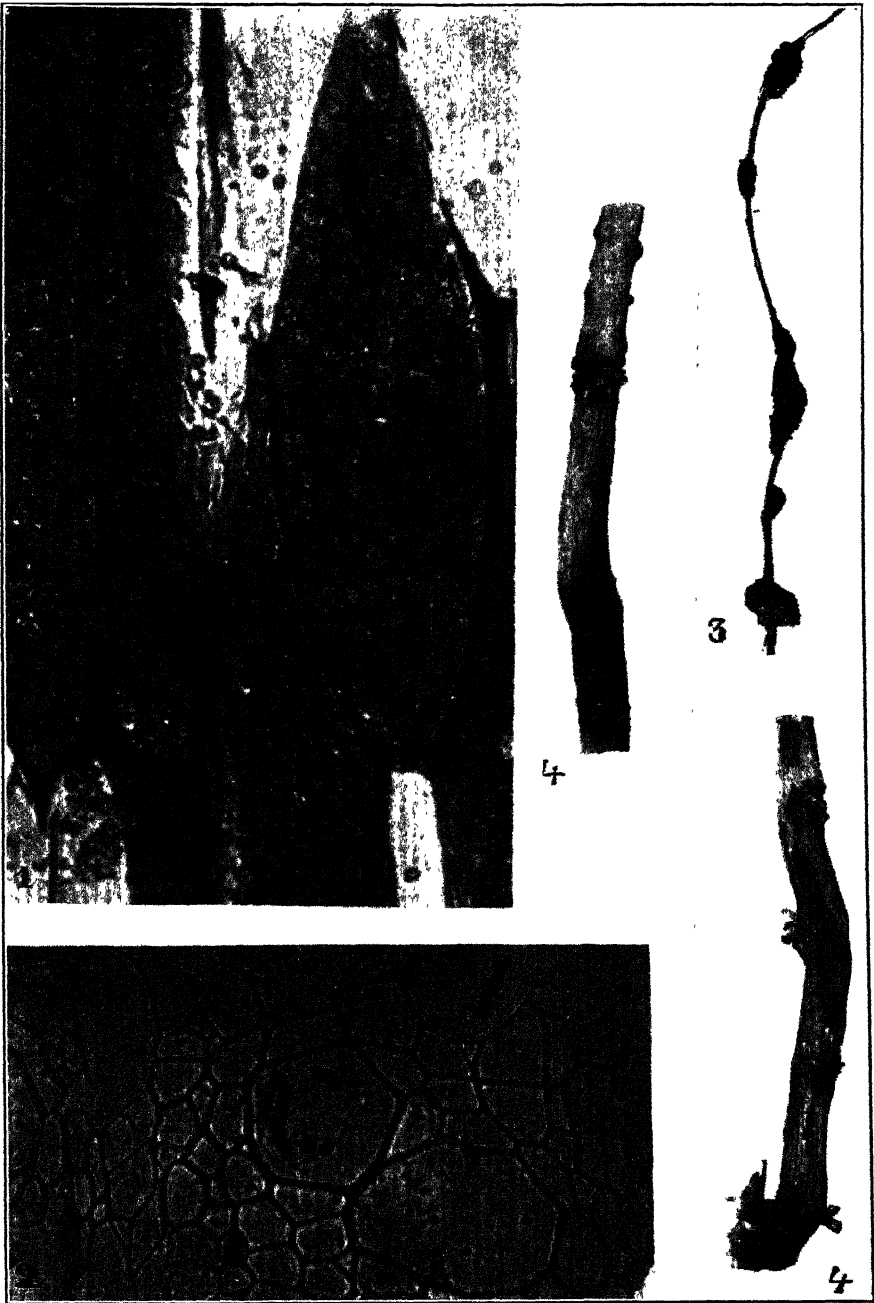
FIG. 5. Cross-section of potato stem showing *Rhizoctonia* sclerotia in the cortical tissue and mycelium in the vascular bundles and in the pith.

The presence of the mycelium constantly observed in the lesions and the permeation of nearly all tissues by this, leaves little doubt in my mind that *Rhizoctonia* is the cause of the trouble. The invasion and plugging of the vascular tissues, diverting the food material going from the leaves to the actively growing parts, or stopping it entirely, account for the production of undersized tubers or no tubers at all. Further, the stopping of the upward current by the plugging of the vessels, especially in a dry season, may produce the curling of the leaves, a symptom nearly always associated with this disease. Naturally, sometimes infections may be slight and no leaf curling will have occurred, but the evidence offered is sufficient proof for the stem parasitism of the fungus.

DIVISION OF BOTANY

CENTRAL EXPERIMENTAL FARM, OTTAWA

DOMINION OF CANADA



DRAYTON: RHIZOCTONIA ON POTATO

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NOTES ON CHESTNUT FRUITS INFECTED WITH THE CHESTNUT BLIGHT FUNGUS

CAROLINE RUMBOLD

In order to test certain theories with regard to the infection of chestnut burs and nuts, a large number of fresh sound nuts and of burs containing nuts were collected in a blight-infected chestnut orchard in October of last year (1913). The burs and nuts of individual trees were tied up in fresh paper bags as soon as gathered, treated with carbon disulphide, so as to kill all chestnut worms, and were then placed in a warm, nearly airtight closet. Here they were in an atmosphere closely resembling that of a damp chamber. The burs and nuts began sweating as soon as gathered and continued to sweat in the closet.

The spores of the chestnut blight fungus which had been deposited on the burs while they were in the orchard quickly developed the characteristic yellow-colored mycelium. In January the nuts were cut open. More than a third of them were found infected with the mycelium of the blight fungus.

The nuts which had remained in the burs formed a large majority of the infected fruits. The burs were the source of infection. The fungus grew from the infected bur through the shell at the base of the nut where there is a close connection between the two and where the hard shell of the nut matures last. Orange colored mycelium showed in patches on the shell around the base of the nuts. Those infected nuts found outside of burs, showed mycelium at their bases, indicating that they had become infected in the burs and had afterward dropped out.

Inside the hard shell of the chestnut uncontaminated growths of the blight fungus were frequently found, although molds, especially *Penicillium* sp., had in some cases penetrated the kernels. Sometimes an aerial mycelium, white or cream-colored, grew around the kernel. At other times very little mycelium showed. The hyphae spread throughout the kernel and could be seen when pieces were put under the microscope. Particles of these kernels laid on nutrient agar quickly produced typical cultures of *Endothia parasitica* (Murr.) A. & A.

As the mycelium spread through the kernel, the color of the latter changed from a glossy yellow to a dull light gray. In January the healthy nuts were so hard it was difficult to bite into them, while the infected

nuts were much softer and somewhat crumbly. Nuts infected with the chestnut blight are extremely bitter to the taste.

Before the harvest of 1913, blight-infected chestnut burs were observed lying under the trees in the orchard; a few infected nuts were noticed, but no attempt was made to find the percentage of infected nuts. In view of the comparative ease with which the nuts in the burs were infected with the blight fungus, the possibility is strongly suggested that there is more than an occasional infected chestnut among the bags of nuts gathered and sold from the blight infected region.

Blight-infected chestnuts were found by Mr. J. Franklin Collins in 1912, and, in his account,¹ he suggested infected nuts as a possible means of the spread of infection. The facts here stated seem to confirm his suggestion.

OFFICE OF INVESTIGATIONS IN FOREST PATHOLOGY

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¹Collins, J. Franklin, Science N. S. 38: 857-858. 1913. The Chestnut Bark Disease on Chestnut Fruits.

THE KNOWN DISTRIBUTION OF PYTHIACYSTIS CITROPH- THORA AND ITS PROBABLE RELATION TO MAL DI GOMMA OF CITRUS

HOWARD S. FAWCETT

Pythiacystis citrophthora (Sm. and Sm.), the lemon brown rot fungus, was previously reported by the author to be the causal agent in one form of lemon gummosis in California. (PHYTOPATHOLOGY, vol. iii, p. 194, June, 1913, and Monthly Bulletin, California State Commission of Horticulture, Sacramento, vol. ii, pp. 601-617, October, 1913). Since these publications, the fungus has been isolated from diseased bark of many gummosis specimens representing all of the important citrus growing localities of California. Many additional inoculations have also been made, all of which confirm this preliminary report. In June, 1913, *Pythiacystis citrophthora* was also isolated from diseased bark of orange trees that appeared to be affected with typical Mal di gomma, or "foot rot" as it occurs in California. Inoculations with cultures of this fungus in July, 1913, into large crown roots of old orange trees have in nine months developed diseased areas which resemble the beginning stages of Mal di gomma. The orange bark, being somewhat more resistant than lemon bark, reacts differently to the attack of this fungus. This fact appears to explain the difference in the general appearance of Mal di gomma and of lemon gummosis in California.

During a recent trip to Florida, Cuba, and the Isle of Pines, the author isolated *Pythiacystis citrophthora* from trees affected with gum diseases in these three places. In Florida, the fungus was obtained from a typical Mal di gomma or "foot rot" specimen. The specimens in Cuba and Isle of Pines from which the fungus was isolated, appeared to resemble more closely the so-called lemon gummosis of California, although found on pomelo trunks.

Prof. R. E. Smith, of the University of California, on his return from a trip in the citrus districts of Southern Europe, reported that he found lemon fruits affected with *Pythiacystis citrophthora* in Sicily in a grove where foot rot was prevalent, and he felt sure from descriptions given him by growers in Valencia, Spain, that it also occurred on orange fruits there. To quote from a letter recently received from Prof. R. E. Smith: "In Sicily I found lemon fruits affected by typical brown rot (*Pythiacystis citrophthora*) in an unmistakable manner. This was in a low-lying, poorly

drained grove where foot rot (but not gummosis of the trunk) was very prevalent. In Valencia, Spain, I inquired about the matter, describing the effect upon fruit, and was told by the growers that they had on oranges the same thing by the name of 'Aguada,' meaning watery. Their description of this form of decay fitted lemon brown rot exactly, both as to appearance and occurrence."

Pythiacystis citrophthora is reported to occur on lemon fruits in Brazil by R. Avena Sacca in Boletín de Agricultura, 13 Series, March, 1912.

The inoculation experiments so far carried out in California, together with the finding of the fungus in Mal di gomma specimens in Florida, indicate that in addition to being the cause of lemon brown rot and one form of lemon gummosis, *Pythiacystis citrophthora* may also be at least one of the causal agents in the occurrence of Mal di gomma.

Further experiments are being carried out to determine definitely, if possible, what relation *Pythiacystis citrophthora* may have to Mal di gomma.

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LINDNER'S ROLL TUBE METHOD OF SEPARATION CULTURES

A. F. BLAKESLEE

WITH PLATE VII

At the Atlanta meeting of the Phytopathological Society, the writer demonstrated an improved method which he had devised and used the year previous for making separation cultures. Since that time he has discovered that the same method had been in use and previously noted by P. Lindner.¹ Since the method is not familiar to the mycologists of this country who have been consulted, and, inasmuch as Lindner's original account is in a brewery journal presumably not accessible to all the readers of this journal, it has seemed desirable to add a note at this place on the subject.

The method is a modification of the Esmarch roll tube method and consists essentially in the substitution of cylindrical specimen jars of quart and half gallon capacity for the ordinary Petri dish. These tubes are plugged and kept upright as shown in plate VII. They are made by Whitall Tatum Co. Jars with a neck apparently better adapted for the cotton plugs are reported by Lindner as sold by the Vereinigten Lausitzer Glaswerken. The advantages of this method over that employed with plates or Petri dishes are the larger number of colonies that can be isolated from a single pouring and the relative freedom from contamination during the operation and later growth. The size of the specimen jars gives the taller molds room for full aerial development, not possible in a Petri dish. A Petri dish sucks in air while the medium is cooling and, with changes of temperature throughout its use, may be pumping in foreign germs. Further, when an inoculation is made from a Petri dish, the cover must be raised and danger of contamination again occurs. The cotton plug in the cylindrical tubes makes these jars as secure from infection as a plugged test tube.

For molds, agar alone has been preferred by the writer and this of course must be filtered or cleared by centrifuging. Tubes previously plugged and sterilized are warmed in a Bunsen flame before using. The tube with the liquid agar is held horizontally under a tap of cold water and rotated on its long axis at the same time that it is jerked vigorously from right to left to prevent the wave of thickening agar from being irregularly dis-

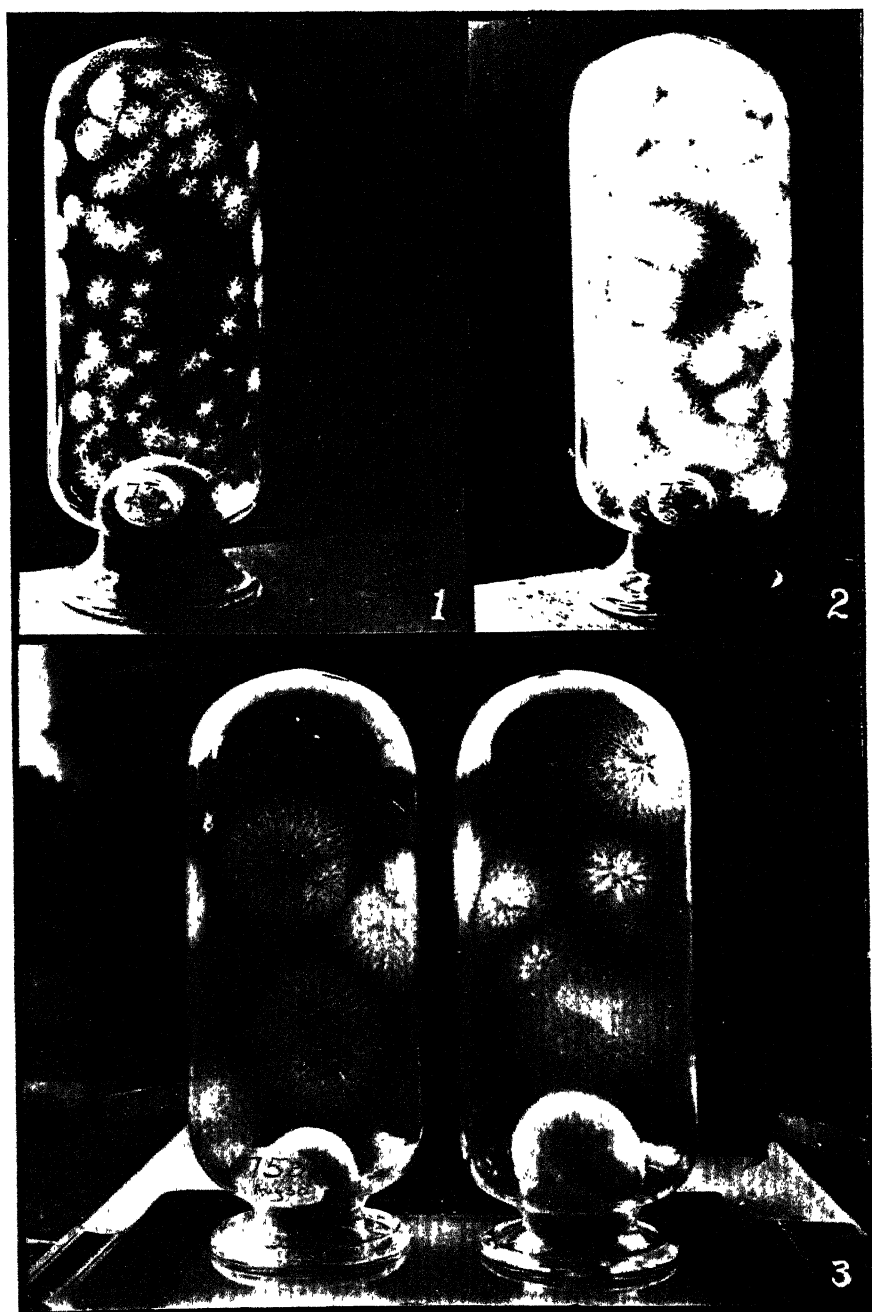
tributed. The tube must be thoroughly cooled or the thin layer of agar will crack upon standing. Usually the first tube is allowed to lie horizontally under a tap or in ice water to finish its cooling while the second tube is being turned and shaken. Water from a tap has been found more effective for the initial cooling than ice, snow, or ice water. If the tubes are stored in an erect position, the cotton plug will absorb the liquid which squeezes out of the agar. The proper thickness of the agar layer on the inside of the tube will depend upon the size of the tube and upon the concentration of agar used in the nutrient. From among a large number of combinations tested by the writer, the following formula has been found most convenient and valuable for the mucors and has been adopted as a standard for this group.

	<i>per cent</i>
Agar flour.....	1.8 to 2.0
Dry malt extract..	2.0
Dextrose.....	2.0
Meat peptone.....	0.1

CONNECTICUT AGRICULTURAL COLLEGE
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EXPLANATION OF PLATE VII

- FIG. 1. Separation culture of a mucor, 3 days old.
FIG. 2. The same as figure 1, 5 days old.
FIG. 3. Two culture jars showing relatively few mature colonies.



BLAKESLEE: LINDNER'S ROLL TUBE METHOD

PHYTOPATHOLOGICAL NOTES

New hosts for some forest tree fungi. During a recent collecting trip on the headwaters of the main North Fork of Clearwater River, St. Joe National Forest, Idaho, some very interesting new hosts for some common forest tree fungi were studied. Specimens of these fungi are deposited in the collections for study in the Laboratory of Forest Pathology, at Missoula, Montana. The most important new hosts found on this excursion are as follows:

Herpotrichia nigra Hartig, or its related form or species, *Neopeckia coulteri* (Pk.) Sacc., on *Thuja plicata* (giant western red cedar), *Abies grandis* (grand fir), *Taxus brevifolia* (western yew), and *Pseudotsuga taxifolia* (red or Douglas fir). The fungus has been observed to spread to various herbaceous and heather-like plants when in contact with the coniferous host. The common mountain heather, *Phyllodoce empetrifomis*, is very frequently so infected.

On hosts previously reported the fungus was surprisingly abundant, particularly in the region around the Monumental Buttes. The leaders of *Pinus monticola* (western white pine) are frequently attacked and killed and at such low elevations that the fungus may be considered of great economic importance. In the same locality at higher elevations *Picea engelmanni* (Engelmann spruce), *Tsuga mertensiana* (mountain hemlock), *Pinus contorta* (lodgepole pine), *Pinus albicaulis* (white barked pine), and *Abies lasiocarpa* (alpine fir) are universally infected. In many cases this results in the entire destruction, or thinning out, of stands composed of these species.

Fomes laricis Fr. is here reported for the first time on living *Pinus monticola*, *Abies grandis* and *Tsuga mertensiana*. *Fomes ignarius* (L.) Gillet was found on living *Rhamnus purshiana* (shittimwood) and *Sambucus glauca* (elderberry). Dead wood in wounds on the former host species was, in two cases, infected by *Coniophora olivacea* (Fr.) Bres., a very unusual habitat for such a pronounced saprophytic fungus, which usually occurs on dead western white pine.

Aside from a very serious and undetermined needle disease which attacks the species, *Taxus brevifolia* is probably more immune from fungous attack than any other conifer. It was with much surprise that *Armillaria mellea* (Vahl.) Quel. was collected from this tree. A larger tree, presumably of great age, exhibited a brown friable heart rot breaking up in

cubes. A small sporophore of *Polyporus schweinitzii* Fr. growing at the base of the tree seemed responsible for the rot.

Polyporus lucidus Leysser (*Ganoderma*) growing on the roots of a living mountain hemlock at 6000 feet elevation was another interesting collection. The mountain hemlock, which attains a fine merchantable size in these regions, was in many places seriously suppressed by *Razoumofskyia tsugensis* Rosend. *Echinodontium tinctorium* E. & E. was abundant on this hemlock. One collection of this fungus was made from the Engelmann spruce, a very rare and unusual host.

JAMES R. WEIR

The potato scab organism. Güssow¹ has proposed the name *Actinomyces scabies* for the organism which causes common potato scab and which has been known in the past as *Oospora scabies* Thaxter. Still more recently Lutman and Cunningham² have stated that in cultural characters it is identical with *A. chromogenus* Gasperini and should be known under that name. In this connection it is of interest to note the opinion expressed by Jacezewski³ in 1910 as shown by the following translation:

"*Oospora scabies* and other related species, isolated by Krüger from beets affected with scab are not true fungi and cannot be included in the genus *Oospora* as characterized by Saccardo for certain Hyphomycetes. These organisms are allied to bacteria and are identical with the forms *Actinomyces*, causing a disease in plant and animal tissues known as Actinomycosis."

M. SHAPOVALOV

The citrus-root nematode (Tylenchulus semipenetrans) in Florida. Until recently the citrus-root nematode, *Tylenchulus semipenetrans* Cobb, has been reported from only one locality in Florida (Cobb, N. A., Journ. Agr. Res., Vol. II, No. 3, June 15, 1914). Thomas (Cir. 85 Univ. Cal.) states that it may be an important factor in the growth of the citrus trees in California and brings out the apparent close connection of "mottled leaf" (a form of chlorosis) and the nematode. In August 1914, the writer found it in the experiment plots of the Florida Agricultural Experiment Station at Gainesville, where a survey of the grounds for this nematode was being made.

¹ Güssow, H. T. The systematic position of the organism of the common potato scab. Science 39: 431-432. 1914.

² Lutman, B. F. and Cunningham, G. C. Potato scab. Vt. Agl. Exp. Sta. Bul. 164. 1914.

³ Jacezewski, A. A. Bu. Myc. and Phytopath. Rep. 6, 1910: 128. St. Petersburg, 1912.

Thirty-five orange trees were examined. Five of these trees had healthy foliage, and showed no infestation with nematodes. The leaves of the remaining thirty were affected with "frenching" (a form of chlorosis). Twelve of the thirty frenched trees were infested with the root nematodes, but the remaining eighteen frenched trees showed no infestation. Most of the infested trees were examined two or more times. The infested and uninfested trees were growing in the same plot and often in the same row, sometimes only twenty feet apart.

Further investigations and experiments are necessary before any final conclusions as to the connection of this nematode with frenching can be drawn.

EDGAR NELSON

A new host for a species of Razoumofskyia. From all published lists of the various hosts of the genus *Razoumofskyia*, one western conifer is conspicuously absent. This is *Pinus albicaulis*, the white bark pine. It is here reported for the first time as a host for one of the several species of mistletoe common on conifers in the West. The first specimen to reach the Missoula Laboratory was collected by Mr. E. E. Hubert, at Wise River, Montana. The second collection made by the writer in the region of the Deerlodge Valley, Montana, is identically the same plant as that collected by Mr. Hubert, except it is more branched and robust. The plant may be tentatively referred to the species *Razoumofskyia cyanocarpa* Nelson. The parasite causes the formation of small compact brooms and considerable hypertrophy of the infected stems.

JAMES R. WEIR

Notes on Rhizoctonia. At a coniferous nursery in the sand-hills near Garden City, Kansas, the writers have found *Rhizoctonia* to be very commonly present in damped-off pine seedlings, apparently having been the chief cause of loss in beds of *Pinus ponderosa* during the present season. Parasitic strains often begin work in the beds before the seedlings come up. The result is that over areas sometimes two feet in diameter no seedlings appear above ground. The parasite continues to spread for six or eight weeks after germination of the pines, causing the damping-off of all pine seedlings within four to eight inches of the edge of the bare area, and of the younger seedlings farther back from the edge. *Rhizoctonia* appears to produce larger single patches of dead seedlings than any other damping-off organism in western nurseries, and to attack seedlings too old to be killed by *Pythium debaryanum* or *Fusarium moniliforme*.

Of the weeds most commonly present in the seedbeds, the Russian thistle seems to be the only one regularly capable of coming up in areas

where the appearance of pine seedlings is prevented by *Rhizoctonia*. Seedlings of *Ambrosia psilostachya*, *Chenopodium leptophyllum*, *Helianthus* sp., and other dicotyledons are found damped off in areas in which the pines are being killed by *Rhizoctonia*. Examination of the soil in the neighboring sand-hills shows *Rhizoctonia* very commonly present in groups of *A. psilostachya*. In some of these groups, underground roots are found to be parasitized to a considerable extent by the *Rhizoctonia*, very definite killed portions covered with hyphae being found in otherwise healthy roots. In such parasitized groups many of the tender shoots sent up from underground roots in the spring are killed before they reach the soil surface, the condition of the stems attacked strongly resembling the condition of the underground portions of the hypocotyls of damped-off seedlings. Only occasional groups of the ragweed are parasitized in this way, indicating either variation in resistance between different groups, or, as seems more probable, differences in virulence in different strains of the parasite. Pine seedbeds on new soil, where such parasitized groups of ragweed had been previously located, have suffered especially from damping-off. Because of the perennial habit of this ragweed it is an ideal host for parasitic strains of *Rhizoctonia* to winter on, and it is suggested that this weed be eliminated as far as possible from soil used for crops susceptible to *Rhizoctonia* injury.

CARL HARTLEY
S. C. BRUNER

Chestnut blight in Nebraska. Specimens of the chestnut bark fungus *Endothia parasitica* (Murr.) And. were collected at two places in Nebraska in September and October, 1914.

On a small grafted Paragon chestnut in the University of Nebraska forest plantation, Lincoln, Nebraska, the disease was found to have girdled the main stem of a tree which was nine-sixteenths of an inch in diameter, but there were still some green leaves above the point of girdling. This tree was one of about 600 shipped from a nursery at Paxinos, Pennsylvania, to a Nebraska nursery in the fall of 1913. Two trees only of the 600 were shipped to Lincoln on April 7, 1914. The other tree was examined but no evidence of the chestnut blight was found.

A lot of 50 or 60 chestnut trees of this same shipment which still remained at the nursery in Beatrice, Nebraska, were examined in October, 1914, and the chestnut bark disease was found on one of them.

While chestnut is not native in Nebraska, the growing of chestnut trees for their nuts is beginning in this state. It is, therefore, of importance that this disease be kept out and therefore that only clean stock be received.

ROY G. PIERCE

Personals. Dr. Arthur Harmount Graves has resigned his position as Assistant Professor of Botany in the Sheffield Scientific School of Yale University, and is at present engaged in research at the laboratory of Prof. V. H. Blackman, Professor of Plant Physiology and Pathology at the Royal College of Science, South Kensington, London, England. Dr. Graves has been a member of the Yale faculty for the past twelve years. His present address is care of Brown, Shipley and Company, 123 Pall Mall, London, England.

Geh. Reg. Rat. Dr. Otto Appel, of the Kaiserliche Biologische Anstalt, of Dahlem-Berlin, has been in the United States since July 15, 1914, to study phytopathological conditions here, as the guest of the United States Department of Agriculture, and some of the leading universities mentioned below.

On July 20-22 he delivered three addresses before the Graduate School of Agriculture, at Columbia, Missouri, on Breeding Disease Resistant Plants and on Diseases of Cereals. On July 27-October 3, he participated in a "potato study trip" made by Department of Agriculture and Experiment Station workers through the principal northern potato sections, from New Jersey and Maine to California, planned with especial reference to potato improvement through control of diseases and official seed inspection and certification.

He has since delivered the following lectures:

At the University of California, Berkeley: 1. The Scientific Fundamentals of Phytopathology; 2. The Breeding of Disease Resistant Plants.

At the 25th Anniversary of the Missouri Botanical Garden, St. Louis, The Relations between Scientific Botany and Plant Pathology.

At the Iowa Agricultural College, Ames, on: 1. The Breeding of Disease Resistant Plants; 2. The Leaf Roll Disease of the Potato.

At the University of Minnesota, University of Wisconsin, and Cornell University, on The Breeding of Disease Resistant Plants and on Potato Diseases.

Dr. Appel will remain in Washington until further notice, pending arrangements for his safe return to Germany.

Dr. Johanna Westerdijk, Director of the Willie Commelin Scholten Phytopathological Laboratory, in Amsterdam, Holland, who has been in the United States since August 12, sailed for home via Genoa, on December 3.

Dr. Westerdijk came first to San Francisco from a year spent principally in Java and Sumatra to investigate plant diseases in the East Indian colonies of the Netherlands. She accompanied the potato study party through Michigan, Wisconsin, and Minnesota, and from Spokane, Washington, to California, later visiting southern California, St. Paul, Madison,

and Washington, D. C. She also attended the anniversary celebration of the Missouri Botanical Garden at St. Louis and delivered a lecture on The Plant Diseases of the Dutch East Indies at the University of Wisconsin and a series of lectures on plant diseases at the University of Illinois.

P. J. O'Gara resigned as pathologist and entomologist for the Rogue River Valley, Oregon, on March 1, 1914, having accepted the position of chief in charge of the Department of Agricultural Investigations for the American Smelting and Refining Company with headquarters at Salt Lake City, Utah.

Dr. G. W. Keitt, formerly scientific assistant in fruit disease investigations, Bureau of Plant Industry, has resigned to accept an appointment as assistant professor in the Department of Plant Pathology of the University of Wisconsin.

Mr. F. V. Rand, scientific assistant in fruit disease investigations, has been transferred to the Laboratory of Plant Pathology, Bureau of Plant Industry. He is succeeded by Mr. L. M. Hutchins, formerly an assistant in the forage plant breeding work of the Bureau.

Mr. R. B. Wilcox has been appointed scientific assistant in the Bureau of Plant Industry, to conduct investigations on the diseases of small fruits.

Dr. E. M. Harvey, of the University of Chicago, has been appointed scientific assistant in the Bureau of Plant Industry, to investigate physiological fruit diseases, and is stationed at Watsonville, California.

Prof. L. H. Pennington has been appointed forest pathologist and professor of forest botany in the New York State College of Forestry, Syracuse, New York.

Mr. Guy West Wilson, recently agent in the Office of Forest Pathology of the United States Department of Agriculture, with headquarters at New Brunswick, New Jersey, has been appointed to the chair of mycology and plant pathology in the State University of Iowa.

Mr. George H. Chapman, assistant botanist of the Massachusetts Agricultural Experiment Station, has returned to his post after a year's leave of absence spent at the University of Prague.

Mr. A. Vincent Osmun has been promoted to the rank of associate professor, and Mr. F. A. McLaughlin to that of instructor, in the Department of Botany at the Massachusetts Agricultural College.

Dr. M. P. Henderson, recently fellow in Plant Pathology at the University of Wisconsin, has accepted a position as Plant Pathologist in the Oregon Agricultural College, in charge of the work in Phytopathology at Medford.

REVIEWS

Bacteria in relation to plant diseases. Smith, Erwin F. Vol. 3, Quarto; pp. i-vii, 309; 155 text figures, 47 plates, including 4 lithographs in color. Carnegie Institution, Washington. Publication No. 27. Distributed August 7, 1914. Price, \$5.

This is the third volume in the monumental task which the author has set himself. It is perhaps commendation enough to say that it maintains the high standards of the second volume. Following the original outline this is wholly given to Vascular Diseases (Continued). The painstaking detail of treatment is exemplified by the fact that 147 pages are given to the two related diseases, Cobb's disease of sugar cane (*Bact. vascularum*) and Stewart's disease of corn (*Bact. stewarti*). Moreover much of this space is occupied with the discussion of inoculations and other experimental studies carried out by the author extending over the last twelve or more years. Among the matters having both scientific and practical interest, may be mentioned under the first disease the observation upon susceptible and resistant varieties of cane. It is encouraging to learn that there is a marked difference in this respect, certain varieties being highly resistant and others very susceptible. This evidence suggests that resistance may be associated with acidity. "The acidity of the cane juice explains, furthermore, to the writer at least, why the bacteria tend to avoid the parenchyma and inhabit by preference the vascular system the juices of which are only slightly acid or neutral." Striking facts are brought out both under Cobb's disease and Stewart's disease going to show that general infection of the plant is largely dependent on rapid growth following inoculation.

Brown rot of the Solanaceae is given about 100 pages. This closes with an appendix giving a critical summary of the recorded observations of writers on bacterial diseases of the potato and tobacco from various other countries. Owing to the numerous scattered and fragmentary publications which are filling foreign literature relative to so-called bacterial diseases of the potato, and the fact that any such might be borne on imported tubers, this part is of value economically as well as scientifically. The conclusion seems justified that, while it is probable that *Bacillus solanacearum* is an almost world-wide parasite upon potatoes, there is, in most cases of potato diseases attributed to bacteria, insufficient or inaccurate data for satisfactory determination of the causal organism.

In view of the difficulty of controlling bacterial diseases it is noteworthy that the author shows that *B. solanacearum* undergoes rapid loss of virulence both on media and in certain soils which fact may offer a way of attack.

Schuster's work upon his German potato rot (*Bacillus xanthoclorum*) is critically reviewed and the author repeated much of it with the conclusion that "the subject is left in such shape that some careful bacteriologist should repeat all of Schuster's experiments, and make others; only in this way shall we finally come to know what weight to give his statements."

The brief accounts of the two Aplanobacter diseases will be especially welcomed by pathologists. These are Ráthay's disease of orchard grass, *A. rathayi* and the Grand Rapids tomato disease (why so awkward a name, Michigan disease would seem more logical) *A. michiganense*. The former is described as a strikingly conspicuous slime disease thus far found only in Austria and Denmark but which is carried on the seed and may be expected in the United States, especially in the cooler, moister regions, e.g., northern New England, or the Puget Sound regions. The extreme brevity of the account of the gross characters or visible signs of the above tomato disease is, however, disappointing, considering that it is believed to be of much economic importance.

In addition there are brief accounts of other diseases including *Bacterium* (*Pseudomonas*) *amaranthi* n. sp., Spieckermann's potato disease, Rorer's Trinidad disease of banana (*Bacillus musae*) Briosi and Pavarino's Italian disease of stock (*Bact. matthiolae*), and Berthet's Brazilian disease of manihot (*Bacillus manihotus*).

The plate work is excellent including the colored plates which enrich the volume. The text illustrations are as heretofore deserving of especial note. In almost every case these are original and from drawings prepared under the author's critical supervision. For example one may refer to figures 47 and 48 showing how *Bact. stewarti* is carried in the seed. The bibliographies are full and accurate as heretofore and the index is commendably detailed.

It is gratifying to find in the text, intimation (p. 207) that the manuscript of volume 4 is in preparation and will include some of the parenchyma diseases. Evidently several more volumes are to be expected.

The profession is again indebted not only to the high ideals and devotion of the author, but to the generous attitude of the management both of the United States Department of Agriculture and of the Carnegie Institution, which in combination make possible the production of a work of such magnitude.

L. R. JONES

LITERATURE ON AMERICAN PLANT DISEASES¹

COMPILED BY E. R. OBERLY, LIBRARIAN, BUREAU OF PLANT INDUSTRY

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All authors are urged to cooperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agric., Washington, D. C.

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PHYTOPATHOLOGY

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THE INVESTIGATION OF "PHYSIOLOGICAL" PLANT DISEASES¹

RALPH E. SMITH

In the development of plant pathology there has always been a tendency to maintain a certain, semi-specific class of diseases as a sort of catch-all for those of unknown and obscure cause. Insects, being the most obvious, were first most thoroughly studied; when fungous parasitism became known, but before its scope was thoroughly comprehended, all troubles and diseases wherein no insect could be found were likely to be ascribed to fungi, "fungous disease" meaning any obscure trouble. As parasitic fungi became better known and methods for their detection and study developed, the term fungous disease became a well defined one. Then came a tendency to ascribe the mysterious troubles of unknown cause to bacteria and "bacterial disease" came often to mean anything not caused by insects or fungi.

Again science has progressed; methods of detecting and studying bacteria pathogenic to plants have been standardized and there is now no reason to ascribe to bacteria any but diseases which can be positively proven to be due to such organisms.

In the meantime there has gradually accumulated a list of diseases, many of them very characteristic ones, for which no specific cause has been found and which do not appear to have any mode of parasitic etiology with which we are familiar. For these the term "physiological" or "non-parasitic" disease has come into use, the idea being, in a general sense, that the trouble is due to an autogenous functional disturbance rather than to the presence of a foreign organism. Included in this class there is at present a variety of peculiar troubles, in some of which there will undoubtedly yet be proven a connection with parasites of recognized

¹ President's address at the meeting of the Western American Phytopathological Society, Corvallis, Oregon, Dec. 30, 1914.

groups. In fact, some of these diseases are continually being taken from the doubtful class and proven to originate in some form of parasitism. A conspicuous example of this is the gummosis of the lemon, a disease which was described by the writer and O. Butler (1908) as a typical, physiological one. A few years later, Fawcett (1913), working at the writer's suggestion and in his laboratory, proved conclusively that the effects produced by this disease are not of autogenous origin but depend absolutely for their inception upon the presence in the tissues of a parasitic fungus. Other physiological diseases may be simply injuries or functional disorders due directly to unfavorable or injurious conditions, although the more specific of the diseases commonly thought of in this connection seem to be more complicated than this.

It is not entirely easy to characterize or define with accuracy the present conception of a physiological disease, although probably it is fairly uniform in the minds of most plant pathologists. Some conspicuous examples of these diseases are peach yellows, bitter pit or baldwin spot of the apple, blossom end-rot of the tomato, exanthema and several other diseases of citrus trees, curly top of the sugar beet, leaf roll, internal brown spot and other diseases of the potato, little leaf of many kinds of trees in California, various types of chlorosis and gummosis, and apple rosette of the western United States. The list might be considerably extended to a point where it would be impossible to draw the line between "physiological" diseases and direct, unquestioned injury from unfavorable or injurious soil or climatic conditions. No argument is needed to show that these diseases have no proven relation to each other. A definition of a class of disease to include them all would amount to something like this: A physiological plant disease is one with specific, well marked characteristics in which no causal relation has been established with any pathogenic organism and with symptoms which do not appear like the effects of parasites of any of the usual kinds. This amounts to saying that it is a disease in which the cause is not known but which does not look like a parasitic one. There is, however, the further conception in these cases to the effect that the trouble is due to a functional or metabolic disturbance in the plant, more or less autogenously incited or maintained. The definition is and must be largely a negative one, since, as we shall soon show, no disease is known positively to be of any such nature.

Good examples of the theory of physiological disease in plants are afforded by some of the various conceptions which have been developed concerning the mosaic disease of the tobacco. Hunger (1905) says: "I consider the virus of the mosaic disease to be a toxin, which is continually being secreted in the tobacco plant in connection with the metab-

olism of the cells and which, under normal conditions, exerts no effect; during too active metabolism it accumulates and then causes such disturbances as the mosaic leaf mottling. I assume that the toxin of the mosaic disease, which is primarily produced by exterior irritation, is able by penetrating into the cell to exert a physiological irritation with the result that the same toxin is secondarily formed there again; in other words, the mosaic disease toxin possesses the property of acting in a physiological, autocatalytic manner." Woods (1899), Heintzel (1899), and others demonstrated that the relative activity of various enzymes in the diseased leaves is abnormal, the former (1900, 1902) formulating the definite theory that the disease is due to an inhibitory action upon starch hydrolysis and translocation, induced by an excess of oxidizing enzymes. Chapman (1913) says: "The direct cause may be found in the presence of free hydrogen peroxide or some other residuary by-product of plant metabolism which has been allowed to remain unassimilated in the cells of the leaves through excessive development and retardation of certain enzymes." He views with particular suspicion the deficiency of catalase which he finds in diseased leaves, seeing in this a possible lack of hydrogen peroxide reduction and consequent injurious accumulation of the latter.

The fact that the tobacco disease is known to be infectious through contact of the juice of diseased plants with healthy plants has not discouraged these investigators in their idea of a non-parasitic origin. They assume an infection by "causative enzymes," similar to that by bacteria or other living organisms, or ignore this phase of the matter.

The present writer (1902) showed in the aster yellow disease a lack of diastatic and oxidizing activities in diseased leaves, together with an excess or accumulation of starch and metabolic by-products such as tannin and organic acids. Sorauer (1909) sees in typical physiological disease "A disturbance of function, or, in other words, a different direction in the molecular motion to which we must ascribe all metabolic processes." In gummosis Beijerinck and Rant (1906) held that "The cells of the cambium contain a cytase, which, while they remain alive, is unable to attack the cell wall owing to the semi-permeability of the protoplasm. When, however, any cells of the embryonic wood are killed by penetrating hyphae, traumatisms or a toxic agent such as mercuric bichloride, the contained cytase diffuses out and is able to attack the walls of the circumambient, healthy cells, which become gummose and finally dissolve away. More cytase is thus released, attacks other healthy cell walls, and in this manner the gum pocket is formed" (translated by and quoted from Butler (1911)). Others have held similar views. Butler (1911) states that "The autogenous form of gummosis appears to be

confined very largely to the cherry and the lemon and is induced when vigorous growth is accompanied by an excess of water in the substratum." "Gummosis degeneration is to be explained in some other way than by assuming the pathological action of an enzyme. . . . I am inclined to believe that were the genesis and development of the cell wall better known gummosis could be explained on a purely physico-chemical basis." Other physiological diseases have been ascribed directly to excess, lack or improper proportion of certain chemical elements in the soil, climatic effects, varietal "running out," inherited weaknesses caused by previous generations growing under unfavorable conditions, biological disturbances in the soil, disturbed osmotic pressure in the plant tissues, and all manner of environmental and functional irregularities.

The writer is attempting a systematic study of some of the most important, supposedly physiological diseases with the purpose of learning the true nature of these troubles and of adding any possible information to our fundamental knowledge of the etiology of plant disease. In carrying out this study and in considering the choice of the most profitable lines of procedure, we have been much impressed with certain fundamental considerations suggested by previous work on these diseases, which may be discussed at this point.

In the present explanations of all the prominent physiological diseases, it is a fact without exception that there is wanting a primary, inciting influence to inaugurate and maintain the structural, functional or enzymatic disturbances which are so easily demonstrated. As to the etiology of even the best studied of these diseases it may be said without exception that in no case has such inciting influence been discovered. The explanations advanced have been theoretical from beginning to end and no proof whatever has been even attempted that the chemical, enzymatic and functional irregularities found represent cause rather than effect or that these conditions are limited to the specific disease under consideration.

The assumption of infection by enzymes or through the transmission of molecular motion has absolutely no foundation of knowledge, is totally at variance with established principles and scarcely merits discussion; it seems more reasonable to seek in such cases the presence of an obscure parasite, as is constantly being done with good results in animal pathology.

We have no absolute proof of the nature of any of the diseases listed above, and no one has ever succeeded in inciting any of them with a specific factor by any method which excluded all possible influence except the one to which he attributed the disease. Indeed we may fairly question whether any specific plant disease has ever been reproduced by any single, well segregated agent except a parasite. We do not assert that real, non-parasitic plant diseases may not or do not exist, but simply

that none have been proven and none of those which are commonly thus classified have been thoroughly studied in some of their most important features. Metabolic diseases are accepted by our more advanced brethren of human pathology, which shows that such functional disorders are not impossible.

Parasitism. Our knowledge of parasitism, either in plants or animals, is by no means exhausted. It is scarcely twenty years since Erwin Smith challenged the skepticism of the European world in regard to the existence of bacterial plant diseases. Still more recent has been most of the development of knowledge of pathogenic protozoa, spirochaetes, sporozoa and filtrable viruses in animal pathology. With these examples before us, who shall say that organized, living parasites of wholly unknown types do not exist? Indeed we do not need to resort to such ultra-considerations as these to show the possibilities of overlooking a parasite, inasmuch as every pathologist realizes the difficulties which often exist in such work.

In the present status of plant pathology the following broad principle cannot be denied: "*There is no single instance known of a positively demonstrated inciting cause of any specific plant disease except a parasite.*"² We have theories, indications, appearances, and effects which point otherwise, but of proof we have none in any case. Therefore, in the investigation of diseases of obscure etiology, should we not first of all proceed from the known to the unknown, disregarding general appearances, indications and theories based on previous, more or less limited experience, and exhaust to the utmost the possibilities of parasitism before confidently declaring our disease to be non-parasitic? The writer speaks with more assurance on this point from having been himself one of the worst offenders. In regard to the so-called yellows of the aster, he stated with assurance (1902), but with no more confirmatory information than is given in this paragraph:

"It is natural in a plant disease to look for some parasitic organism as the cause. In many respects the appearance and nature of this disease lead one to suspect some such origin, but it may be said at once that the most careful search in all parts of the plant has failed to reveal anything of the sort. That the trouble is purely of a physiological nature, due to some perversion of the normal functions of the plant, can scarcely be doubted." At the present time we would be loathe to discuss the extent of the "most careful search" which proved so conclusively that no parasite is present in this disease!

² Specific means here, of course, something more complicated or obscure than direct traumatic effects.

Again in discussing gummosis of citrus trees we stated (1908): "It may be said here without extended discussion that in no case have we been able to recognize or demonstrate the presence of any fungus, bacterium or other parasitic organism as the cause of any form of citrus gum disease. . . . We feel safe in concluding that the diseases hereafter described are of a physiological or autogenous nature. . . . The appearance and occurrence of the diseases is not such as to point to parasitic infection as the primary cause." And yet a few years later Fawcett (1913), in the same laboratory, proved the most prevalent type of the disease to be due to an easily isolated fungus of a genus and species first described by the writer himself. In regard to the curly top of the sugar beet, we stated (1907): "The conclusion reached and substantiated by a great variety of field and laboratory investigations, observations and experiments extending over two seasons, has been that the trouble is not brought about by any parasite or organism, but is rather due to a derangement in the normal functions of the plant. . . . The disease is one of a number of so-called physiological diseases." We hope soon to be able to offer proof that this disease is strictly of parasitic origin, from investigations now going on.

Having before him these examples of his own errors in this respect, the writer is inclined to be over-cautious perhaps in accepting similar statements from others. Are we certain that the possibilities of parasitism have been exhausted or even thoroughly considered in the tobacco disease,³ bitter pit of the apple, blossom end-rot of the tomato, peach yellows, aster yellows, and other diseases of this class? We say this with no criticism or disparagement of the work done upon these diseases except as to its completeness upon this one point.

Difficulty in proving parasitism. The ordinary methods of demonstrating parasites are well known, consisting of direct examination with the microscope with or without staining, making of cultures from diseased tissues, and attempts to produce infection. The difficulties of proving parasitism in individual cases are many and varied. There is, first of all, theoretically at least, the possibility that types of parasites may exist of which we have no knowledge or conception. If, however, we add the more recently discovered types of animal pathogens to our usual list, we may busy ourselves for some time before exhausting present resources.

A second source of difficulty or error lies in the fact that the parasite may be located in another part or organ than that in which the visible

³ Allard's recent work (1914) shows almost certainly that the inciting factor in this disease is of the nature of a filtrable virus, as suggested by several previous investigators.

or most striking effects of the disease appear. In the "mottled leaf" disease of citrus trees Thomas (1913) has shown the existence of a very abundant parasitic nematode of an entirely new species upon the roots of affected trees, where previous investigators had not made a careful examination. Humphrey (1914) has just shown proof that the "western blight" of the tomato, previously considered a physiological disease, is due to a fungus attacking the finest rootlets under certain conditions. Many similar instances suggest themselves. Therefore all parts of the plant must be thoroughly studied and searched for a possible parasite and not simply the part where the most prominent effect is seen. Criticism on this point is justified in almost all the work that has been done on physiological diseases.

The parasite may attack the plant only at a certain or for a limited period and disappear before the symptoms of the disease are outgrown or even before they are well developed. This applies more especially to insects, worms, and such animal parasites than to fungi or bacteria.

Parasites are very often refractory to the usual staining, culture or other methods of detection, and there may be some which are impossible to detect with certainty in the host tissues and many we know *will not* grow in a culture by any of our present methods. The most exhaustive researches by the latest methods of bacteriology, parasitology and cytology should be made before the search for visible parasites or foreign bodies of any kind in the tissues is concluded. The mere fact, too, that cultures have been attempted on the ordinary media without success is no proof that parasitism does not exist. In reporting results the investigator should state clearly the media and methods which he has used unsuccessfully and avoid such statements as "various media" or "the usual media" were employed, as though this settled the matter.

Infection takes place in some cases under such limited circumstances that one may see or culture the right organism but not hit upon the necessary mode or time of infection. The loose smuts and some of the insect-transmitted animal parasites are examples of this. Also curl and California blight of the peach.

Again, difficulty in proving parasitic etiology may easily occur in the case of diseases where certain specific lowering of or change in the resistance of the host, or an invigoration of the parasite is necessary before infection can take place. Certain degrees of temperature, soil or atmospheric humidity, light intensity, nutritional relations, and other factors may accomplish this.

Lastly, as regards parasitism, the mental attitude of the investigator, a preconceived notion that certain diseases are non-parasitic, has probably

done more than anything else to discourage thorough work along this line.

Let us repeat that we would by no means be understood as holding that all plant diseases are necessarily parasitic ones. We particularly deprecate the burdening of the literature of some of these diseases with poorly established, easily disproven claims of supposed parasites, as has so frequently been done. We suggest only that none of the so-called non-parasitic troubles has been sufficiently investigated in this respect, that from time to time a careful investigator shows that his predecessors have overlooked something, that there is at present no established group of non-parasitic diseases for the kind of troubles which we are considering, that we should not abandon too soon the known for the unknown, and that the investigator should at least, in publishing his results, state exactly what methods he employed and the attendant circumstances, avoiding general statements to the effect that the search for parasites has been exhausted.

Symptomatology, histology, cytology, diagnosis. In studying a new or poorly known disease there is nothing more necessary than that we should have definite means of detecting the disease in all stages and sharply distinguishing it from all other effects. This can always be done where a specific organism can be detected and to a certain extent is possible by means of gross, morphological changes and symptoms. Such symptoms, however, are rarely adequate and may not appear at all in the earliest stages of the disease, when in many cases it can be studied to the best advantage. Color changes, irregularities of growth or form, premature or partial death and similar symptoms are all of value and should be carefully looked for and described, especially when found with certainty to be characteristic of the specific disease under consideration. But preceding and causing such symptoms there must always be present functional or tissue disturbances which may often be capable of demonstration by histological means. Such symptoms, moreover, are of great value in studying the etiology and development of obscure diseases. Animal pathologists long ago arrived at *cellular pathology* as the last resort in diagnosis, and the plant pathologist can do no less if he would solve his most obscure problems. Through all our discussions of "enzymatic disturbances," "molecular motion" and "functional disorders," and our empirical applications of chemicals, fertilizers, water and various other substances in a blind effort to stumble onto something of promise, the fact remains that in no single instance (except to a certain extent in gummosis) do we have any accurate or comprehensive idea in these diseases of the cytology or histology of affected plants. In some cases we know that certain tissues die or are discolored but that is about all.

Let one read the recent edition of Mallory's Pathological Histology, written from the standpoint of human pathology, and he will realize the value of such knowledge and its deficiency in plant pathology. Let him study Erwin Smith's (1912) photomicrographs of crown gall and ponder on our knowledge of peach yellows, judged by the same standard. In the study of obscure diseases we should get at the very beginning a comprehensive, accurate knowledge of all pathological changes of structure in the whole plant so far as they can be detected by histological or any other means. We should attempt to detect the very first inception of the disease and follow its effects throughout. Knowledge of general effects upon tissues is not sufficient but we must go down to a clear conception of the condition of the cells and their contents. This necessitates a similar study of the normal plant for purposes of comparison and may often involve considerable difficulty in obtaining specimens known to be absolutely free from the slightest degree of the disease. Not only in the case of obscure and physiological diseases is such study needed, but likewise with plants affected with diseases or lesions of known cause, we need a vast amount of accurate work upon the specific structural and functional effects of all pathogenic influences; each bit of information of this sort added to our store of knowledge furnishes one more possible clue to the detection of unknown causes of disease by comparative study of effects.

One of the most important phases of the kind of work just discussed has been thus far almost entirely neglected in the investigation of physiological diseases. *Histological study should not be confined to the part of the plant where gross lesions or abnormalities appear, but should include every part and organ.* Our meagre knowledge of the pathological histology of bitter pit and of blossom end rot, for instance, is confined to the fruit, where prominent, gross symptoms appear. Nothing is more desirable than a careful, histological study of the whole plant in these cases. Mr. A. Bonquet, a graduate student in our laboratory, has found that in the case of the apple disease lesions occur in the vascular tissue at least as far back as the stem, and in fruit not yet fully grown. Comprehensive work of this sort will undoubtedly eliminate some theories and strengthen others as to the etiology of these diseases. Similarly with parasitic diseases, traumatisms or intoxications, we need to know the effects, if they exist, upon the whole plant and not simply those in the vicinity of the initial disturbance or the most obvious effects. Such accurate, complete knowledge would undoubtedly aid greatly in the elucidation of our obscure problems.

The investigator should search especially for *characteristic* symptoms, for *initial* ones and for the *totality* of significant effects, so that he can

proceed to describe the symptomatology and pathogenesis of the disease in such a manner that future investigators and students may have the minimum of uncertainty in identifying the same disease.

Pathological physiology and biochemistry. The biochemical work already done upon some of our obscure diseases, as well as upon some of known parasitic origin, has revealed great possibilities for comprehensive, thorough research in this direction. Technical knowledge of the methods and status of similar work in animal pathology is needed for such work. Wells' Chemical Pathology and Zinsser's Infection and Resistance are of great value to the investigator in this connection, as well as being most readable to any person interested in pathology.

A danger of fragmentary biochemical work in connection with these diseases lies in the lack of discrimination between cause and effect of the disease, which characterizes most of the work which has been done thus far.

Conclusion. In conclusion the writer may summarize his ideas on this subject as follows:

There is no such thing as an established group of physiological or non-parasitic plant diseases for the kind of troubles which we have been considering. There is among them not even a single, well proven example. They are all more or less obscure diseases of unknown etiology, which, for one reason or another, have not yet been accounted for.

In all diseases found to be really infectious, either through inoculation with plant parts or juice, by budding or grafting or by any transmission method producing true infection in normal plants, it is best to assume a parasitic factor.

The only positively known inciting factors in plant disease (excluding direct traumatisms) are parasites. In the investigation of diseases wherein an obscure, ever active, inciting factor appears to be present, we should therefore proceed from the known to the unknown, endeavoring within reasonable limits to exhaust every known phase of parasitism before assuming conceptions of no established importance.

Nothing is more important than a thorough knowledge of the pathological histology and cytology in these diseases, although such knowledge is at present extremely lacking.

Biochemical work is likewise of great importance but may easily be so superficial as to result in false and misleading conclusions.

The study of these diseases should include every part of the plant and not simply those where gross symptoms or lesions appear.

The most substantial proof should be obtained before final conclusions are drawn. Tentative or incomplete results may be worth publishing but should be clearly stated as such, with the attendant methods

and circumstances, giving the reader an opportunity of drawing conclusions of his own. Many facts but few conclusions is a safe rule in such cases.

A thorough knowledge of pathological histology and chemistry of diseases of known cause is equally important, especially for the elucidation of obscure troubles by comparison.

The greatest progress in fundamental knowledge of plant disease can be made only by pathologists; not mycologists, physiologists, bacteriologists, cytologists, or chemists, but men who combine an intelligent interest in and appreciation of these elements in their relation to the study of disease.

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LIGHTNING INJURY TO POTATO AND COTTON PLANTS

L. R. JONES AND W. W. GILBERT

WITH PLATES VIII AND IX

The fact that lightning often causes serious injury to trees of various kinds is well known, and botanical literature contains many articles describing the nature and extent of such damage in all parts of the world. References to injury of field crops or other herbaceous plants by lightning are much less frequent. Indeed we find no published records of this nature from America and few from Europe. We believe, however, that such injuries are not uncommon, at least on the two crops named in the title. During the last two years the authors have been observing these independently, the one (Jones) on potatoes in Wisconsin, the other (Gilbert) on cotton in South Carolina. The likeness of the phenomena makes it seem wise to combine discussions.

LIGHTNING-STRUCK COTTON

It is a matter of common knowledge to cotton growers of the southern states that cotton fields are liable to injury by lightning. Two cases of such injury came to the attention of the junior author in adjoining fields at Monetta, South Carolina, in the summer of 1913. In both cases the injury was noticed shortly after a severe electrical storm which occurred at midday on August 3, and it was noted by the owners that the lightning struck in the locality where the injury was later discovered. The fields were visited and the plants examined by the author, August 28. At the time when struck by lightning the plants were nearly full grown, two to four feet high, the earliest bolls practically mature, but none opened as yet. The soil was light sand. In the first case examined, all the plants were killed over an area some three rods in diameter. We were told that following the storm the leaves on these plants promptly wilted, died and blackened but remained clinging to the plants. The bolls soon began to turn pale, yellow and dry up, but failed to open. By observations in other years and conversation with experienced cotton growers, we have learned that a dead spot in the field as described above represents the common type of injury both as to size and symptom. Such lightning-struck spots in a field are easily distinguished even at a distance by their round shape and the almost coal-black color of the dead leaves. If the lightning

strikes after cultivation ceases, as in the above case, this area soon grows up to cocklebur or other weeds (pl. VIII, fig. 1). Between the central area, where the plants were all dead, and the surrounding uninjured field, there was a zone of plants showing diminishing degrees of injury. Some of these plants lived for days or weeks. The leaves meanwhile slowly changed their color to a yellow or brick-red, suggestive of the autumnal tints of certain trees, drooped and finally blackened and died. Figure 2, plate VIII, shows such a plant with leaves and boll still clinging to the branches.

On pulling up some of the dead plants it was noted that in all cases the immediate effect of the injury was most pronounced on the stem and root system from the surface of the soil downward. The bark here was dried, sunken and darkened, and, at the juncture of this with the uninjured bark above, there was a slight shoulder or ridge as shown in plate VIII, figure 3. This bark injury extended entirely around the stem. Where the injury was less severe, so that the plant continued longer alive, a distinct callus was formed beneath the bark just above the dead tissue. This is well shown in figure 4, plate VIII, where the pronounced callus growth, entirely surrounding the stem, has ruptured the bark on the dead portion at several points forming cracks of one-fourth to one-half inch in width. In this instance, also, a new sprout pushed out above the callus to a length of some two inches. The moist soil conditions following the storm prolonged the life of the plant for some time in spite of the injuries to the root system, but as soon as the surface soil again dried out the plant died. In a few cases, the inside of the stem of these lightning struck cotton plants was discolored in a manner resembling that characteristic of the wilt or *Fusarium* disease, but this malady does not occur within several miles of this place. Moreover, examination of these stems showed no *Fusarium*. No cracking of the bark or splitting of the wood was observed as a direct effect of the lightning injury, nor was there any evident disturbance of the soil about the plants.

Two other cases on an adjoining farm differed from the one already described in that not all of the plants within the central portion of the lightning-struck area were killed. Instead, the injury occurred in smaller groups, two to six plants in a place; some dying immediately and turning to the characteristic black color, others changing more slowly, the leaves reddening first, while still other adjacent plants showed no injury, whatever. The injured plants showed symptoms identical with these from the typical lightning-struck area on the adjoining farm. There seems no doubt that their death was due to lightning, although no fully satisfactory explanation is offered for the difference in phenomena. The close proximity of a small persimmon tree in one of these latter fields and of a hedge in the other may have had some influence on the strength and distribution of the electric current.

LIGHTNING-STRUCK POTATOES

During each of the last three mid-summers, 1912-1914, the senior author has been receiving reports of the sudden death of the plants in sharply defined, somewhat circular areas or spots, in potato fields. In every case reported these have appeared in July when the Wisconsin potato is at its highest vegetative vigor. Moreover, this is the season when thunder storms are most prevalent here and in numerous cases the farmer attributed the loss to lightning. Nevertheless, when the first cases were reported to us, we made critical examinations of the afflicted plants, both in laboratory and later in the field until satisfied that there was no parasitic organism associated with the trouble. Experience teaches the pathologist to be cautious in accepting popular opinion as to the causal relation of lightning or electrical currents with mysterious plant maladies. We have, therefore, been gratified when during each of the last two summers convincing evidence has come to us that lightning is the cause of this trouble. We will cite one case in detail.

John Cherf, an experienced and successful potato grower at Antigo, Wisconsin, had in 1913 a fine field of uniformly healthy, vigorous potatoes growing immediately adjacent to his residence. On or about July 12 while watching a severe electrical storm from his window overlooking this potato field, there came a blinding flash of lightning immediately before him. As soon as the storm passed he made examination in the direction of the flash and found evidence that the bolt had struck in his potato field about twelve rods from the house. The potato tops appeared broken and dishevelled over a small area, and upon drying off within 24 hours, they wilted and died. When examined by the senior author some three weeks later, the plants were all dead and dried up over a circular area about twelve feet in diameter. Immediately bordering this dead area, many of the plants showed injury, but aside from this the plants over the entire field showed a splendid stand of vigorous growth. The injured plants, still living, showed partial collapse and death of the stem from a little below the ground line upward through one-half their length, more or less. The tips were living and below ground the base of the stem, roots, stolons and young tubers seemed uninjured (cf. pl. IX, fig. 1). Indeed in some cases new sprouts were starting up from the bases of stems of which the aerial parts were nearly or quite dead. In several other fields examined the conditions were essentially the same except for variation in diameter of the spots which ranged from some eight to ten feet in the smaller ones to two to four rods in the larger (pl. IX, fig. 2). In no case have we had opportunity to examine the plants immediately following the lightning stroke, but plants taken a few days thereafter appear as follows. In the

mildest cases the injury occurs as a shrunken region about at the surface of the soil. The stem soon collapses here and the top falls over. Meanwhile the stem shrivels and browns progressively above and below this point, but fastest above (pl. IX, fig. 1). The pith in this region dies, browns and collapses, giving hollow stems but without rapid soft rot such as may occur with the bacterial black leg. Microscopic examination and cultures have failed to discover any bacterial or fungus organism considered parasitic. In the advanced cases with stems still living, the tissues are shrunken and collapsed for three-fourths of the length, from a short distance below the ground line nearly to the tip. Some of the partially injured stems immediately bordering the dead area gradually die, so that the spot tends to increase slowly in diameter for a week, but thereafter remains unchanged. No evidence of splitting or mechanical rupture of stems has been observed.

It will thus be evident that neither the individual plants nor the affected spot as a whole bears any close resemblance in appearance or development to any known potato disease. This, with the evidence which in at least three cases has coupled the inception of the injury with observed lightning strokes and the belief of numerous potato growers that lightning is the cause, has convinced us of the correctness of this interpretation.

It is only necessary to record further that these spots have been seen in Wisconsin on both sandy and clay loam fields, and that their distribution seems in no way dependent on the contour of the land. As we have observed them, they may occur in perfectly level fields, and in rolling fields they may appear at lower elevations as well as at higher.

Upon the publication of the abstract of this paper in the December issue of *PHYTOPATHOLOGY*, Professor F. C. Stewart wrote us that he had observed a couple of similar cases in New York potato fields last summer. These so closely corresponded to our description of lightning injury that he accepts this as the explanation of their occurrence. "In each case there was a single circular area in which the plants were mostly dead. The spots were 15 or 20 feet in diameter."

No similar injury to the other neighboring field crops has been observed by either author. Nor has conversation with colleagues brought out evidence of such except in the case of sugar beets. Miss V. W. Pool tells us that in Colorado the beet growers believe that lightning may kill sugar beets in spots. We have similar reports relative to lightning injury in tobacco fields. Mr. J. W. Brann, who is investigating the diseases of ginseng in northern Wisconsin, tells us of two cases of lightning injury to this crop which came under his observation. Ginseng is grown under artificial shade consisting of a lath screen supported on posts. In both of these cases the posts were struck and split by the stroke. In one case

it killed the aerial parts of the plants for a radius of some two feet about the bottom of the post, but the roots showed no apparent injury. In the other case it killed practically every top (aerial part) for a radius of ten feet about the post. Moreover, it killed practically all of the fibrous roots of these plants, but left the fleshy tap root with its terminal bud apparently unharmed. As indicating how different the result may be with different plants we have the statement of Mr. W. A. Orton that he saw a field at Blackshear, Georgia, where the line dividing a crop of cotton and corn (maize) passed through the center of a lightning-struck spot. On one side the cotton was killed over a semicircular area in the manner described in this article; across the line some of the corn stalks were split by the stroke, but no further injury was evident and none of the corn plants died. On the other hand, Dr. E. T. Bartholomew tells us that he has seen in a Kansas corn field a circular area something like two rods in diameter where all the plants had been killed, supposedly by a lightning stroke. It seems certain, however, that such lightning injuries to corn and grain crops cannot be as frequent as we have noted in potato and cotton fields else they would have become a matter of common knowledge among farmers. Of course, these fields are equally exposed to such electric discharges and if injury occurred it would be especially conspicuous in such crops. Meteorologists recognize the liability of lightning to strike in open fields and on comparatively level surfaces.¹ Dr. Bartholomew has told us farther of a Kansas observation where he saw lightning strike in a grass field, setting fire to dry grass. The land was undulating and rose to a gentle hill on one side of this field with woodland on the other. This corresponds with our observations in potato fields that such strokes show no marked preference for higher elevations or objects.

COMPARISONS WITH EUROPEAN RECORDS

We have found no reference to lightning injury to cotton, but Colladon² reports the effect of lightning injury to grapes which resembles the damage to cotton in some respects. These include the circular area affected, with greatest injury at the center, the slower death of some plants and the brick-red coloration of their leaves.

¹ See Abbe, Cleveland, *Monthly Weather Rev.* **32**: 323, 1904. Dr. Abbe recognizes the lesser liability of such a stroke upon a smooth plane surface as of still water, but points out how lightning may strike upon such irregularities as waves of water and minor projections from land surfaces, and cites evidence of such occurrences.

² Colladon, Daniel. *Effets de la foudre sur les arbres et les plantes ligneuses* Mém. de la soc. de phys. et d'histoire nat. de Genève **1872**: 548-553.

Rathay³ has also noted the reddening of the leaves of lightning-struck plants and states that, in all authentic cases, it resembles the red coloration resulting from mechanical ringing of the branches, the injury in both cases being principally to the cambium layer.

Frank and Sorauer,⁴ Colladon,⁵ Appel,⁶ and Spieckermann⁷ all have published notes on lightning injury to potatoes.

Appel records that these evidences of lightning stroke appeared in spots including some rather broad areas. In these the plants in the middle were at once killed while nearer the margin of the affected area they were so torn and weakened as to become an easy prey to *Fusarium*. Dr. Appel in conversation further tells us that in one field he saw several such spots of which the larger was some fifteen feet in diameter. He has also seen local injuries to grapes due to lightning where an area of twice this size was involved. Similar cases of killing of sugar beets have come under his observation where instead of one large spot there would be three or four smaller spots.

Colladon also describes the lightning as killing potato plants in spots of which one was six meters in diameter. He notes evidences of physical injury to the stems and Steglich (quoted by Frank and Sorauer) describes these as split and torn with ragged wounds.

Colladon and Seelhorst⁸ describe injuries from lightning strokes in beet fields. Seelhorst speaks of one case where the injury covered a circular area about fifteen meters in diameter. In the middle of this area the beets were entirely killed; in the outer parts the leaves of some of the plants were yellow or withered with intermingled plants showing slight injury. In the fleshy roots of the injured beets small cavities appeared, especially in the upper portions.

³ Rathay, Emerich. Ueber eine merkwürdige durch den Blitz an *Vitis vinifera* hervorgerufene Erscheinung. Denkschr. d. math.-naturwiss. Klasse d. Kais. Akad. d. Wissensch. Wien. 1891.

⁴ Frank and Sorauer. Jahresber. über die Thätigkeit des Sonderausschusses für Pflanzenschutz. Jahrbuch der Deutsch. Landw.-Gesellschaft 7: 208. 1892. (Record observations by Steglich.)

⁵ Cited by Sorauer, P. Handb. d. Pflanzenkr. 1: 495. 1909 (3rd Ed.).

⁶ Appel, Otto. Mitt. a. d. Kaiserl. Biol. Anst. f. Land. u. Forstw. 5: 19. 1907.

⁷ Dr. O. Appel informs us that Spieckermann recently published briefly on this in Berichte d. Landkammer f. Westphalien. We have not been able to consult this, however, or verify the citation. This author has a brief note under the title, Kartoffelpest oder Blitzschlag. Prakt. Blätter f. Pf'bau u. Pf'schutz. 1907: 103.

⁸ Seelhorst, V. Rübenbeschädigung durch Blitz. D. Landw. Presse 31: 515. 1904.

EXPLANATION OF THE PHENOMENA

The evidence as to the nature of the lightning injury to these herbaceous plants is too fragmentary to furnish ground for a satisfactory explanation of why it is more serious upon some crops than others. Evidently the conditions are quite different with these low succulent plants than obtain with lightning injury to trees. In the latter the current passes the full length of the plant through relatively resistant tissue and the injury may occur throughout the length of the trunk. With the potato and cotton the injury occurs chiefly at or near the ground line. It seems clear that the lightning does not strike the individual plants generally over the injured area or at least that the main force of the electric current does not pass through the length of their stems. Instead the evidence indicates that the discharge is from the surface of the soil. In conference with Dr. Lyman J. Briggs of the Office of Biophysical Investigations, Bureau of Plant Industry, we have formulated the following explanation as best in accord with our observations. When an electric storm breaks suddenly following a period of dry weather and the first rain wets the top soil, there remains a layer of dry earth between this wet surface and the moist soil underneath, which is a poor conductor of electricity. When the lightning strikes the wet surface soil, it disperses in all directions, horizontally and then downward into the earth, following lines of least resistance. The plant stems and roots with their abundant water content are better conductors than the layer of dry soil just mentioned and so the electrical current passes through them. The tissues may thus be variously injured or killed depending upon the amount of current passing through them. With the cotton, it seems that the higher water content of the bark and cambium may make these regions the especial paths thus explaining why the injury appears greater in these.⁹

The strength of the current, of course, diminishes the farther it gets from the center of the affected spot, and consequently the lessened injury at the margins of the area. In some cases apparently the discharge may be broken and "strike" in several spots, near together.

This explanation seems in general accord with the idea as to injuries to plants by lightning or other electrical current as set forth by Stone and Stahl.¹⁰

It still remains to ask why some plants, e.g., cotton, potatoes and beets, seem more liable to injury than others, e.g., grass, grains and corn. It is

⁹ See Stone, G. E. and Chapman, G. H. Electrical resistance of trees. Mass. Agr. Exp. Sta. Rpt. 24: 144. 1912. Also, Stone G. E., Electrical injuries to trees. Mass. Agr. Exp. Sta. Bul. 156. 1914.

¹⁰ Stahl, Ernst. Die Blitzgefährdung die verschiedenen Baumarten. 1912. (Jenu.)

possible that the amount of injury is proportioned to the degree of resistance shown by the tissues and that the potato and cotton tissues are less favorable conductors. This may perhaps be determined by experiments. Again it is conceivable that the character and distribution of aerial parts or root systems, respectively, may in the one class of plants be more favorable to gradual electric discharge as compared with the tendency to electric accumulation and resultant lightning stroke in the other class. The greater number, uniformity of distribution, and similar height of the leaf or stem apices of corn, grains, and grasses seem to make this a tenable theory, since these numerous points would seem more favorable for such gradual discharge than would the aerial parts of potatoes, beets, or cotton.

EXPLANATION OF PLATE VIII

FIG. 1. Cotton field showing circular areas, about in the middle of the photograph, where plants were killed by lightning and weeds have grown.

FIG. 2. Cotton plant killed by lightning, leaves and bolls still clinging to the branches.

FIG. 3. Lightning killed cotton plant showing shrunken darkened portion below the callus ridge at *a*.

FIG. 4. Lightning struck cotton plant which died slowly, showing pronounced callus formation at *a* with splitting of the dead bark below and young sprout above.



FIG. 1. Lightning injury in cotton field. (See explanation of plate.)

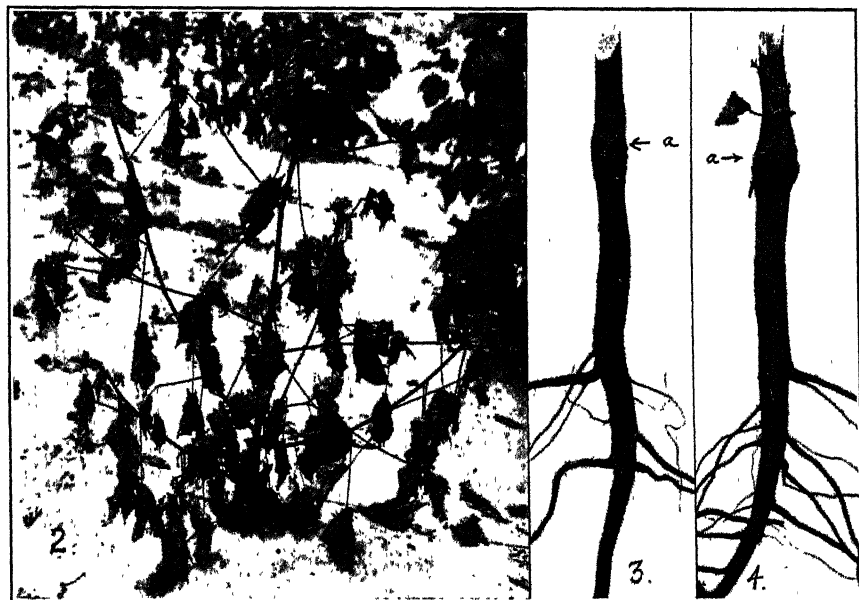


FIG. 2. Lightning killed cotton plant. FIGS. 3, 4 injured stems. (See explanation of plate.)

EXPLANATION OF PLATE IX

FIG. 1. Potato stem injured by lightning. From the margin of a lightning-killed area. It was evident that the initial injury occurred near the soil line, the roots being intact and the base of the stem alive and firm. The aerial portion of the stem was collapsed and black for two-thirds its length (a-a). The bases of the petioles and lateral branches (b, b) were also collapsed but the leaf blades were uninjured except as they were wilting through lack of water.

FIG. 2. Spot in a potato field, Barron County, Wisconsin, killed by lightning stroke. Note that this is on fairly level ground. Such injuries have been observed on perfectly level fields, on hillsides and in lower areas, with no evidences that topography influences location. Lightning struck on July 11, 1914, photographed in August by F. D. Otis.



FIG. 1. Potato stem injured by lightning. (See explanation of plate.)



FIG. 2. Spot in potato field killed by lightning. (See explanation of plate.)

NEW LIGHT ON CURLY TOP OF THE SUGAR BEET

RALPH E. SMITH AND A. BONCQUET

WITH THREE FIGURES IN THE TEXT

The purpose of the present note is to record certain interesting facts which have been ascertained in a study now going on of curly top of the sugar beet.

Corroboration of relation of Eutettix tenella to Curly top. The evidence of Ball¹ (1909) and Shaw² (1910) as to this peculiar disease being incited by the sting of the minute leaf hopper, *Eutettix tenella* Baker, has never been fully accepted by entomologists and pathologists, owing to the unique importance of the fact and various points claimed to be lacking for absolute proof. Our work has, we believe, settled this question in the affirmative beyond any question. First we repeated the methods of Ball and Shaw, covering beet plants with gauze tents and cages, thereby confining the insect upon or excluding it from certain plants. This was done in the open field and also in the greenhouse, with plants grown from the first in insect-proof cages to exclude all but the individuals being experimented with. The results were uniformly in accord with those of the previous investigators. Curly top developed freely in plants attacked by this particular insect, and in no others. To further refine our methods sugar beet seed was planted in four-inch pots and two plants allowed to grow in each pot, keeping the whole in a *Eutettix*-proof cage from the first. After each plant had about 8 to 10 leaves, a single insect was confined in a vial upon one of the two plants in each pot, as shown in figure 1. In each case the plant thus infected showed the typical disease after the usual incubation period (about two weeks, in the greenhouse), while the other in the same pot did not.

In applying the insect for different lengths of time, it was found that as short a period as five minutes is sufficient to produce the disease.

A lesion and an organism in affected plants. All of the various gross symptoms and morphological types of this disease described by previous

¹ Ball, E. D. Leaf Hoppers of the sugar beet. U. S. Dept. Agr., Bur. Ent. Bul. 66, pt. iv. 1909.

² Shaw, H. B. The curly top of beets. U. S. Dept. Agr., Bur. Pl. Ind. Bul. 181. 1910.

writers (R. E. Smith³ (1907), Townsend⁴ (1908), Ball (l.c.), Shaw (l.c.)), together with some which they did not describe, are correlated with a specific interior lesion, always present in a greater or less degree in affected plants. This lesion is found in the phloem, in all parts of the plant where any visible, macroscopic irregularities appear, and to some extent where they do not appear, i.e., before their development. This effect consists at first in a denser-appearing condition of the cell contents of certain areas of sieve tubes and companion cells, followed by more or



FIG. 1. Curly top developed in one of two sugar beets in same pot, by application of *Eutettix tenella* in a vial for five minutes on one leaf.

less necrosis, collapse, discoloration, and often, in the end, development of new, irregularly formed, wound-healing cells in these areas. These lesions are sometimes scarcely more than small areas of slightly irregular cells in the phloem, while again they may be large discolored, necrotic pockets visible to the naked eye in the petioles and main veins as well

³ Smith, Ralph E. Beet blight investigation. In Cal. Agr. Exp. Sta. Bul. 184: 240. 1907.

⁴ Townsend, C. O. Curly top, a disease of the sugar beet. U. S. Dept. Agr., Bur. Pl. Ind. Bul. 122. 1908.

as in the roots. Figure 2 gives a diagrammatic idea of the location of these lesions in a vascular bundle of a large vein. They can be detected in lesser degree in the finest ramifications of the veins of curly top leaves.

From a long series of cultures it has been found that a certain specific bacterial organism appears to be a constant inhabitant of the tissues of sugar beets affected with curly top. This organism has been obtained very regularly from all parts of affected plants, even after the most severe surface sterilization with mercuric bichloride, and also by cutting out pieces of tissue with a flamed scalpel. More attention has thus far been devoted to the leaves than to the roots, and it is from these organs especially that the organism has been so regularly obtained by means of

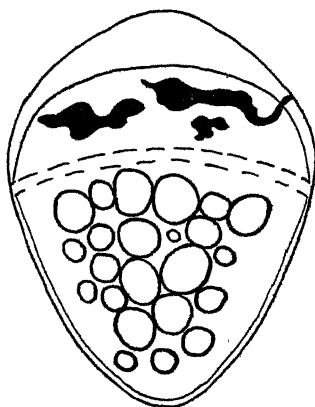


FIG. 2. Diagrammatic representation of location of lesions in vascular bundles of leaf veins.

cultures (by the ordinary bouillon tube isolation method). The leaf shown in figure 3 represents a typical case. In this leaf may be seen the visible indications of curly top in the lower three quarters of the left side and extreme lower right hand portion. After soaking for ten minutes in 1-1000 mercuric chloride solution in water and subsequent thorough washing in sterile, distilled water, bouillon tubes were inoculated with pieces of tissue from different parts of the leaf.

Pure cultures of the usual organism developed in the four tubes made from those portions of the leaf where the visible indications of the disease appear, while four tubes from the upper right hand half of the blade remained sterile. Numerous similar results were obtained in other cases. Here again the characteristic phloem lesion could be found underlying every swelling and irregularity seen on the surface (under) of the leaf.

The organism found agrees with *Bacillus dianthi* Bolley⁵ (1896), originally described as the cause of the carnation disease afterward called Stigmonose. This organism has been found abundantly as a saprophyte



FIG. 3. Typical, partially-affected curly top leaf, from which *Bacillus dianthi* developed uniformly in cultures from left side, after severe disinfection, but not from right side. Phloem lesions also present in correlation with this.

in soil and on the surface of healthy beet leaves and is particularly abundant on the surface of beet seed. After surface sterilization, however, it disappears completely except in the case of curly top tissues. Beet

⁵ Arthur, J. C. and Bolley, H. L. Bacteriosis of carnations. Ind. Agr. Exp. Sta. Bul. 59. 1896.

leaves sickly, yellow or partially dead from other causes do not show it at all under such conditions.

Curly top not produced by infection with B. dianthi. We have not succeeded in producing the disease by inoculating plants with this organism. We do not know whether it is the true inciting factor, causing and inhabiting the lesions described, a harmless invader, or a co-agent with some other factor.

Curly top transmissible by grafting. By grafting buds, connected with wedge-shaped pieces of root tissue, from diseased beets into the "shoulders" of healthy ones, we believe that we have produced the typical disease in each of the few instances thus far tried.

Microscopic detection of organisms in diseased tissues. Much difficulty has been encountered upon this subject. In the lesions above mentioned certain bodies of an apparently living nature are often detected, but whether they can be taken for *B. dianthi*, wholly or in part, or what their real nature may be, has not yet been decided. Further work is necessary upon this matter and upon the general subject of the specific nature of the effect of *Eutettix tenella* and the ontogeny of the disease.

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SOME PROBLEMS OF PLANT PATHOLOGY IN REFERENCE TO TRANSPORTATION

F. L. STEVENS

The purpose of this paper is not to present new facts but rather to suggest what is perhaps a new, or at least a little discussed viewpoint. The pathologist usually concerns himself with the occurrence of disease in the field or at the point of production, or with local storage troubles, much less frequently with questions as to what may happen to a plant product after it leaves the hands of the producer.

Questions of great importance may, however, arise concerning the changes which occur in transit, especially in the case of long hauls or of particularly perishable freight. Two or three illustrations may make the meaning clear and serve as the basis for further discussion.

Take the case, for example, of a carload of peaches originating in an orchard heavily infected with the monilia stage of *Sclerotinia fructigena*. Before packing all peaches known to be infected are discarded. The fruits to casual observation are sound when placed in the cars. When they arrive at their destination many show incipient or even well-developed rot. Again, a shipment of lettuce is made from a plantation infected with *Sclerotinia libertiana*. The plants visibly affected are sorted out. The shipment is badly affected at destination.

The product in both of these cases was infected when consigned. The history of the case and our knowledge of the spread and development of *Monilia* convince us that the peaches were diseased when shipped. In the case of the lettuce, since the fungus does not form conidia and, under these circumstances, may be spread only by contact, we may be sure that if infected at destination the shipment was also infected at the starting point. It appears clear to the writer that in both of these cases the responsibility rests with the shipper, just as much so as it would if a consignment of horses already infected with glanders but not yet showing the disease was placed upon the cars.

A case somewhat less clear might occur in a shipment of grapes which upon arrival is found to be badly affected with blue mold (*Penicillium*). We know that this fungus is a wound parasite, that it can gain entrance only through breaks in the skin. Such breaks may occur in picking, in packing, or may be due to the fact that the berries are over ripe, therefore

soft. On the other hand, they may be due to rough handling in the cars. The necessary spores are ever present, probably already upon the fruit, and yet no damage results without mechanical injury first. The responsibility clearly rests with the one permitting such mechanical injury.

Cases of an entirely different class are represented by the scab diseases of apple, potato, and peach. Each is of such slow development that it is inconceivable that even in very long slow hauls it could increase appreciably.

Other factors which enter into consideration are those of time and temperature. A consignment of asparagus or lettuce in prime condition if kept in a warm, humid atmosphere long enough, will rot in one or another way. In the language of the court they are "inherently liable to deterioration and decay."

The question of responsibility, therefore, will often hinge upon this "inherent susceptibility." How long under different temperature and humidity conditions will plant products remain wholesome? For present purposes, perhaps the following classification of diseases will help to clarify conceptions.

A. Slowly developing diseases which under no conditions will increase appreciably within a period of a few days.

Examples: Wheat smut, apple and peach scab, apple blotch and scab, *Ascochyta* of pea, potato scab, *Fusarium* and *Phytophthora*, tomato blossom end rot, watermelon anthracnose.

B. More or less rapidly developing diseases which can normally originate only at point of production.

a. Rapid:

Examples: *Monilia* of peach, various bacterial soft rots (?), plum and cherry *Monilia*, *Sclerotium Rolfsii*, canteloupe rots, *Sclerotinia libertiana* on lettuce, *Botrytis* on lettuce.

b. Less rapid:

Examples: Apple bitter rot, black rot, and pink rot, grape black rot, bean anthracnose, celery *Septoria*, egg plant ascochytose.

C. Rapidly developing diseases which can occur only on wounded plant parts.

Examples: *Rhizopus* on strawberry and sweet-potato, *Penicillium* on grapes, apples and oranges. Various bacterial rots, e.g., celery, asparagus, onion, et cetera.

D. Rapidly developing diseases which occur only on wilting or old products or under unsuitable condition of temperature or humidity.

Examples: Bacterial or mold infections of many kinds, *Rhizopus*, *Penicillium*, bacteria, et cetera.

Class A we understand well. All of the more important cases have probably been studied and described. We know also the general nature of classes B and C. The causal agents are well known but not the effects of temperature and humidity upon the rate of progress of the diseases. Class D is the one which presents the greatest inaccuracy of knowledge. Indeed, we possess as yet very little real knowledge which will enable us, for example, to say how old, under a given condition of temperature and humidity, a tomato may be without becoming liable to the decay which is its "inherent nature." Nor can we say with any accuracy how detrimental to keeping quality would be a change of a few degrees of temperature. Really accurate answers to such questions as these are of much importance, both because they will enable us to enlarge our power of control over these diseases and because the answers to the questions often involve determination of large financial responsibilities.

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A SUGGESTION OF A NEW PHASE OF THE PROBLEM OF PHYSIOLOGICAL DISEASES OF PLANTS

C H A S. B. L I P M A N

The vagueness of the general term physiological plant diseases has of late been heightened by an increase in the number, diversity, and economic moment of manifestations which for want of a better classification have been relegated to that niche in the plant pathologist's cabinet. Despite the great volume of work which has been expended on that most troublesome group of plant ailments, the fundamental principles involved in their causation still remain shrouded in a thick veil of mystery. In an uncertain manner we ascribe their origin to some functional irregularity in the affected plant which may be induced by a variety of agents. Whether our methods of attack in attempting to solve these difficult problems have been ill advised or our conceptions with respect to them erroneous, it is not the purpose of this brief paper to discuss. Suffice it to say that the economic significance of "physiological diseases of plants" has in recent years assumed colossal proportions and scientific investigations with respect to them have contributed but little to their solution.

The foregoing observations on the present status of the subject under consideration have suggested to the writer other aspects of the problem which in turn hinted at new avenues of attack. Preliminary experiments based on such ideas, as explained below, indicated the existence of certain abnormal conditions in the soils upon which affected plants were growing which have since been found to obtain in many soils of California on which various physiological plant diseases occurred. It is only with a view to discussing these findings that these lines are written, in the hope that they may be pregnant with many suggestions for further work in a field which is certain to make grateful returns to the investigator sooner or later. The writer being, in a sense, a layman in the field to which his present readers largely belong, offers his observations in no spirit of criticism of past work, nor with any attempt at aspersion of such work and therefore ventures to hope that his observations will receive the consideration of patient thought, and his methods of a wider test than they are now receiving.

In another publication¹ the writer has pointed out that decidedly abnormal conditions, with respect to the nitrogen supply obtain in certain of our California soils upon which die-back (exanthema) and mottled leaf of citrus trees occur extensively. The abnormal conditions consist principally in a poor supply of available nitrogen but it is not infrequently found that the total nitrogen supply in such soils is very low. What is further of great interest is the fact that the meagre supply of available nitrogen referred to is not necessarily due to a lack of total nitrogen, but to incapacity on the part of the soil's flora, to render available such nitrogen as is present. In other words, the bacterial flora of a given soil, especially under the conditions of our arid valleys, may be capable only of rendering available the nitrogen contained in certain nitrogenous materials and not in others. Curiously enough the amount of nitrogen contained in a given material, as the writer will soon show more in detail elsewhere, does not appear to influence the degree of its transformation by the flora in question. Thus dried blood, a "high grade" nitrogenous fertilizer, may be worse than useless as a source of nitrogen to plants growing on the "abnormal" soil, if nitrifiability may be considered a criterion, whereas cottonseed meal or low grade tankage may have their nitrogen readily changed to nitrates by the various groups of nitrogen transforming bacteria present in that soil. Lest one might, however, gather from the latter statement that materials low in nitrogen are more readily attacked by the particular class of soil flora under discussion, it must be added that such flora are able to transform the nitrogen of materials of the highest grade into nitrates about as efficiently as the "low grade" materials just mentioned. Sulfate of ammonia for example, may be mentioned as such a material.

The foregoing statement merely gives a hasty sketch of the relation of certain "die-back" and "mottled leaf" soils, studied by us, to nitrogen as referred to in the paper above cited. Since those studies were carried out, however, we have found a similarly abnormal condition to exist widely in our interior valley soils on which such other physiological diseases as little leaf of the vine and little leaf of deciduous trees as well as general backwardness in growth are prevalent.

Based on the foregoing considerations the writer has offered the definite theory in lieu of, though in a sense consonant with, the vague one of malnutrition, that the physiological diseases mentioned above and perhaps others, are caused by an insufficient supply of available nitrogen, involving in some cases not only nitrogen hunger but internal disturbances in the cells owing to their growth in unbalanced solutions as media. The

¹ Science, n. ser. 39: 728.

word theory is intended to serve in its most complete significance here since on the plant side the writer possesses in support of the idea, conclusively, only greenhouse experiments in pots, besides the laboratory investigations on the nitrogen content and powers of nitrification (for different materials) possessed by the abnormal soils under consideration. While field experiments in test of the theory are now proceeding no conclusive data have as yet been obtained.

That the general idea of malnutrition, with respect to nitrogen, of the affected plants in the cases of the diseases above named, may have many phases and the causative agents vary widely under different soil and climatic conditions, is indicated by the following possibilities in the direction of an insufficient supply of available nitrogen.

1. The total nitrogen supply may be very low and hence an insufficient supply of available nitrogen is almost certain to follow.

2. In soils in which sufficient nitrogen is supplied the form of the latter may render it unsuitable for transformation to nitrate by flora existent in that soil.

3. In soils high in carbonates, particularly those of the alkali earths, ammonia may be set free as rapidly as it is formed by the ammonifying bacteria and very little nitrate be produced in those soils as a result. In such cases nitrogen starvation would be expected.

4. A possibility which was suggested in the paper above cited is one which appears of lesser importance in the light of our recent results, and that is the toxic effect of ammonium compounds directly assimilated by plants in soils incapable of producing nitrates. In any event, of course, this could only occur in plants which are injured by nitrogen in the form of ammonia.

The conditions, in turn, which may contribute to those just named are numerous. So far as the total nitrogen supply is concerned it is well known to all soil chemists who have an intimate acquaintance with California soils that the latter taken by and large are very poorly supplied with that element. This is most strikingly the case in the lower Sacramento and the San Joaquin valleys and in the desert valleys of the state including the Imperial and Coachella valleys, and the San Bernardino region. The total nitrogen in very many of these soils may be found to be equal to 0.01 per cent or 0.02 per cent. It is only the great advantage of the soils' depth in the arid regions, taken as a whole, that makes possible the normal growth of some plants on such soils. In other words, a large internal soil surface with a small nitrogen content when open to root development serves in lieu of a small soil surface with a higher nitrogen content. If for any reason, however, the greater soil depth should not be available to root development by reason of a bad physical con-

dition, the presence of hardpan or other interference, it is obvious that the amount of nitrogen in the shallow surface soil layers available for root development, will soon become inadequate for the plant's support and trouble of some kind is bound to ensue.

In the event of a sufficient supply of total nitrogen on the other hand it is easy to conceive of soil conditions which could inhibit the transformation thereof into available form. In the first place as our experiments show, the soil flora may be such as to require nitrogen in certain forms in order to render it "available" or to transform it into nitrate. Any unsuitable form of nitrogen, no matter how good it may be from the chemical standpoint may not only fail to yield nitrates in the soil but may actually be instrumental in causing losses in the soils' original nitrate supply. In addition to such conditions, however, many other conditions may contribute to a soil's inefficiency in the direction of transforming organic nitrogen into nitrates. Poor drainage, bad physical conditions, acid reaction of the soil, excess of soluble salts of a certain nature, excess of difficultly decayed cellulose material, may all very seriously hinder the transformation of soil nitrogen to nitrates. In the case of a crop accustomed only to nitrate nitrogen or preferring it, such soil conditions must directly or indirectly operate to produce nitrogen starvation.

In connection with the last possibility above mentioned of a poor available nitrogen supply it must be stated that the field experience with die-back in citrus trees of Florida would seem to give it some support. In that state it has been often noted that the disease has been aggravated by the employment of nitrogenous fertilizers in certain organic forms. This can be explained on the basis of the loss of the soils' nitrate supply subsequent upon the introduction of say blood or high-grade tankage as above indicated. But it can also be considered as lending support to the idea of direct absorption of ammonia by the citrus tree (since ammonification of such organic nitrogen may proceed normally in those same soils), and thus causing disturbances in the tree growth through toxic effects as explained.

In brief, it would seem that a large variety of soil conditions due to the mode of a soil's formation or to effects following from certain methods of management might contribute to the circumstances above categorically enumerated. Field observations as well as the laboratory and greenhouse experiments described in this paper are almost wholly in support of the theory herein set forth. It is further a significant fact and one strengthening the foregoing ideas, that in soils poor in nitrogen the diseases named manifest themselves after two or more seasons subsequent to planting indicating an assimilation and depletion of the nitrate nitrogen stored in the soil (in many cases a virgin one) to the point at which nor-

mal plant growth can no longer continue. In the possibility of toxic effects from direct absorption of ammonia we should also expect the manifestation thereof to come after two or more seasons as it appears to do in the case of die-back in lemons.

In the greenhouse experiments mentioned in support of the ideas above enunciated, we have found it possible to produce normal growth of orange seedlings in soils from "die-back" areas only by the application of materials which are readily nitrified by those soils, e.g., sulfate of ammonia, carbonate of ammonia, and chloride of ammonia. Good results were also obtained with sodium nitrate, but the effect was not nearly as striking as in the case of the ammonium compounds just mentioned. During the term of these experiments which are still in progress, orange seedlings grown on the untreated soil have made little or no growth, despite the fact that they have been exposed for about two years to the dust-laden atmosphere of the greenhouse which could be reasonably expected to change the soil's biological nature.

In the case of grain, also, a relationship between the soil's nitrogen supply and normal growth has been observed by us which is very similar to that above described for various fruits. A more detailed discussion of that subject is given in a paper which is soon to appear.² In a paper by Brooks which appeared in this JOURNAL³ recently similar causes to those here discussed are hinted at as being concerned in the production of blossom end-rot in tomatoes.

Based very largely, therefore, on studies concerned with the total nitrogen content of soils and with the variation of the latter in power to nitrify different forms of nitrogen, and in a minor way on the greenhouse studies above described, the writer suggests the possibility of curing the diseases above described by direct or indirect soil treatment (depending on the conditions above indicated) of a nature to insure a good supply of available nitrogen. In soils poor in humus it would appear to be best to employ sulfate of ammonia, or cottonseed meal, while in soils rich in humus dried blood and high grade tankage are likely to give better results. It is not expected, moreover, that such treatment in the field is likely to be followed by quick improvement in the affected plants. The reason for this is that a tree root or vine root covers a very large area of soil and it is not possible to influence that large foraging surface of the plant's roots quickly. Nevertheless, large applications of the materials named, along with a good water supply and thorough tillage to insure the maximum degree of distribution of the nitrogenous materials should go far to assist and hasten the process of the plant's recovery.

² Proc. Soc. Prom. Agr. Science, 1914.

³ Phytopathology 4: 345.

One more point deserves consideration in this brief general statement of the writer's suggestion regarding the causative agents of some physiological diseases of plants. The question may naturally arise as to how one advancing the theory above briefly considered could account for good individual plants or groups of such which are, frequently, perhaps generally, found in the diseased areas. In other words, on the assumption that the soil is all alike in a given area we should expect to have all plant growth alike. This argument however is erroneous since there is no uniformity in soils to begin with, but even if this is set aside as of minor importance here, it must be remembered that individuals among plants as well as animals, are frequently more resistant than their fellows to untoward conditions. If in a given soil with a deficient supply of available nitrogen one plant should develop a much larger root system than its neighbor, it is obvious that it would have at its disposal a much larger amount of plant food since its roots would cover so much more internal soil surface. It is therefore not a valid argument against the theory here promulgated that the soil near good plants as well as that near bad plants in a field is poorly supplied with nitrogen in an available form. Such a fact would only indicate that the condition of the whole field was bad and that good plants are produced in parts thereof in spite of conditions and not because of them, through individual plant powers to obtain the necessary nourishment which are not possessed by plants in general in that same field. In cases, however, in which the soil surrounding the good plant does differ in nature from that of the poor plant in the same field, explanations for the differences can be easily given as indicated in one of the papers above cited.⁴

I wish to reiterate here that I am merely proposing as a justified theoretical consideration to connect certain very troublesome functional troubles in plants known as cases of malnutrition or as physiological diseases with a definite lack of a specific plant food element—nitrogen—in available or usable form. I do not desire to be understood as attempting dogmatically to explain the unexplained, nor, to lay claim in any sense to finality in my statements. Despite all that, the observed facts as above described are very striking, and the experimental results thus far obtained most encouraging. It is the writer's earnest hope that those interested in plant nutrition problems will at least give his theory the courtesy of a carefully controlled test and thus help us to arrive sooner at a proper understanding of its validity and practical significance.

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⁴ Proc. Soc. Prom. Agr. Science, 1914.

THE RÔLE OF SUCKING INSECTS IN THE DISSEMINATION OF FIRE BLIGHT BACTERIA

V. B. STEWART AND M. D. LEONARD

Since the experiments conducted by Waite¹ who demonstrated that bees are important in the spread of blossom blight, various agents have been associated with the dissemination of the fire blight organism, *Bacillus amylovorus* (Bur.) Trev. It has been shown by Whetzel² that man himself is often an active agent in spreading the disease and it is believed also that birds frequently carry the bacteria.

Without question all insects which occur on host plants susceptible to blight are capable of carrying the causal organism, though it is probable that many of these species are not instrumental in producing new infections. The very nature of the method of introduction of the bacteria precludes the possibility of this. Any insect that comes in contact with the germ-laden, gummy exudation of the blight disease may, no doubt, carry the bacteria to other trees, but the possibility of infection taking place depends upon the introduction of the causal organism into the host tissue. Repeated experiments have shown conclusively that except for blossom blight, the bacteria gain entrance and produce an infection in the host tissue only through a wound or injury. From this fact it is therefore natural to infer that insects which feed by sucking the plant juices are more likely to spread the disease. They visit exuding blight lesions, become smeared with the gummy substance and carry the infection material to other shoots. Here some of the bacteria are deposited in the feeding punctures made by the insects and produce new blight infections. Insects which do not puncture the tissues in feeding are perhaps less apt to spread twig blight. They are of importance only in carrying the fire-blight bacteria to wounds in the tissue such as mechanical injuries and the like.

The experiments and observations made by the senior writer³ show that the tarnished plant-bug (*Lygus pratensis* L.) is capable of carrying

¹ Waite, M. B. Life history and characteristics of the pear blight germ. Proc. Amer. Assoc. Adv. Sci. 47: 427-428. 1898.

² Whetzel, H. H. The blight canker of apple trees. New York (Cornell) Agr. Exp. Sta. Bul. 236: 104-138. 1906.

³ Stewart, V. B. The importance of the tarnished plant-bug in the dissemination of fire blight in nursery stock. Phytopath. 3: 273-276. 1913.

the causal organism to healthy shoots where the bacteria gain entrance to the host tissue through the feeding punctures made by the insect. Forbes⁴ was probably the first writer to attribute to the tarnished plant-bug the capability of spreading the fire blight disease. He says, "There is considerable reason to suppose that these insects are often active agents in conveying the virus of the blight of the pear and apple from tree to tree by inoculation with the infected sap."

The constant appearance of other sucking bugs during the growing season and their association with outbreaks of the fire blight in the nursery, prompted further experimental work by the writers in order to determine whether any of these insects were capable of producing fire blight infections. For the experiments such species, occurring on apple stock, were selected as could be collected most easily in sufficient numbers and which also were believed to be most important in transmitting the fire blight organism. The names of the species are as follows: *Adelphocoris rapidus* Say, *Campylomma verbasci* Herrick-Schaeffer, *Orthotylus flavosparsus* Sahlberg and *Poeciloscytus basalis* Reuter.

Young apple seedlings with succulent shoots were also selected and the insects for the experiments were obtained from weeds at some distance from the nursery plantings rather than from the nursery trees themselves. This was done in order to eliminate as far as possible, any chance of using insects already smeared with fire blight bacteria due to their having visited diseased trees. Cylindrical cages, about 15 inches in height and 4 inches in diameter, made from wire-cloth, 12 meshes to the inch and covered with cheese-cloth, were used to cage the bugs over each tree. The bugs were transferred to the cages and the cages inverted over the trees, care being taken not to injure the shoots during the operation. A six-days-old, pure, agar culture of *Bacillus amylovorus* was employed for all experiments, the culture being smeared on the tips of the shoots by means of a camel's hair brush.

EXPERIMENT 1

Campylomma verbasci Herrick-Schaeffer. Length, about 3 mm.; upper surface greenish gray or a dirty grayish white; thorax often tinged in the middle with darker; antennae with two blackish rings near base; legs spotted with black; underside of abdomen brownish or black. Breeds commonly on the mullen, *Verbascum thapsus*.

The experiment was allowed to run from July 7 until July 22, 1914, when the final results were recorded. In two of the cages some of the bugs remained alive throughout the first seven days of the experiment.

⁴ Forbes, S. A. The tarnished plant-bug. Farmer's Review, Feb. 28, p. 150, 1884.

The tips of the six shoots of three trees were smeared with the agar culture of *Bacillus amylovorus* and ten specimens of *Campylomma verbasci* caged over each tree. When the cages were finally removed four of the six shoots were badly blighted; the failure of the other two shoots to become diseased was attributed to their hard and woody condition, rendering them more resistant to the disease.

Ten bugs were allowed to run over an agar culture of the causal organism for one hour and then caged over a tree with four shoots. Two weeks later three of the shoots were blighted.

The eight shoots of three trees were smeared with the culture, but the bugs were excluded from the cages placed over the trees in order to protect them from other insects. None of the shoots blighted on these check trees.

Ten bugs were caged over a tree with three shoots, but the culture was not smeared on the tree or on the bugs. All of the twigs were healthy and free from injury two weeks later.

EXPERIMENT 2

Orthotylus flavosparsus Sahlberg. Length, about 3 mm. This little insect may be readily recognized by the fact that it is light green in color and the whole body is sprinkled with white. It is found commonly throughout the summer months in the region of Ithaca, New York, on *Chenopodium album*.

This experiment was set up July 22 and final notes taken August 3, 1914. The six shoots of three trees were smeared with a culture of *Bacillus amylovorus* and fifteen specimens of *Orthotylus flavosparsus* caged over each tree. Two weeks later all six shoots were badly blighted.

Fifteen bugs were caged over a tree with three shoots but the culture was excluded. All of the trees remained healthy.

The seven shoots on three trees were smeared with the agar culture, but the bugs were excluded from the trees by means of the cages. None of the shoots were blighted when the final observations were made August 3.

EXPERIMENT 3

Poeciloscytus basalis Reuter. This Capsid is very similar in appearance to the lighter colored specimens of the tarnished plant-bug. It is slightly smaller, however, being about 5 mm. in length; the yellowish mark on the scutellum is never Y-shaped or broken into three distinct spots, but is wedge-shaped, narrowing posteriorly. Instead of a yellowish spot on the wings there is a reddish or orange marking.

The following experiment was started July 29, 1914, and completed August 11. The seven shoots of three trees were smeared with an agar culture of *Bacillus amylovorus* and about twelve specimens of *Poecilocyttus basalis* caged over each tree. The final observations were made August 11 when four of the seven shoots were blighted. Owing to the continued dry weather, the shoots made but little growth throughout the experiment. Those which blighted did not suffer so severely as the shoots in previous experiments, due to the hard and woody condition of the tissue which rendered them more or less resistant to the active progress of the disease.

Several of these insects were allowed to run over an agar culture of the causal organism for twenty minutes after which ten of them were caged over each of two trees. Two weeks later five of the seven shoots on the two trees were badly blighted.

Seven shoots on three trees were smeared with the agar culture and the insects excluded. Cages were placed over the trees to protect them from the attacks of other insects. All of the shoots remained healthy.

Ten bugs were caged over a tree with three tender shoots and the culture was excluded. At the conclusion of the experiment, the shoots were free from disease. Two of the shoots showed a slight discoloration, probably due to the feeding punctures of the bugs, but the injury did not develop any further and the trees remained healthy.

In several of the cages, some of the bugs were still alive at the close of the experiment.

EXPERIMENT 4

Adelphocoris rapidus Say. Length, 5 to 6 mm.; head and front margin of thorax reddish brown, remainder of thorax yellowish, with two large dark brown or blackish spots, which are sometimes confluent, thus forming a transverse band; wings brownish, bordered on the outside with yellow and with a reddish spot about two-thirds the distance back; antennae yellow, alternately banded with dark brown or red; eyes dusky; legs reddish brown; feet dusky at tip.

The experiment was set up July 29 and completed August 11, 1914. The three shoots of one tree were smeared with an agar culture of *Bacillus amylovorus* and nine nymphs (stages 3, 4 and 5) and one adult were caged over the tree. Two weeks later all these shoots were badly blighted.

Ten nymphs (in several stages) were caged over a tree with three shoots which had been smeared with the culture. After ten days the cage was removed and all the shoots were blighted.

Four bugs (two nymphs and two adults) were caged over a tree with two shoots, but the bacteria were excluded. After a period of two weeks

both shoots were free from disease and no injury was apparent. One of the adults was still alive when the cage was removed.

As a check on this experiment, the ten shoots on four trees were smeared with the agar culture of the organism and the bugs were excluded. Cages were placed over the trees to protect them from the attacks of other insects. All of the trees remained healthy.

From the results of the experiments conducted it is apparent that all of the above named species are capable of producing fire blight inoculations when the causal organism is present, and are undoubtedly instrumental in spreading the disease.

Where the insects were allowed to run over the agar culture of *Bacillus amylovorus* and then transferred to the trees, nearly all of the succulent shoots blighted. Also a large percentage of the shoots became diseased when smeared with the agar culture and the bugs caged over them. The insects attacked the tender tips of the shoots and produced lesions in the tissue which afforded an entrance for the blight bacteria. In all cases where either the agar culture of the causal organism or the bugs were excluded from the trees, none of the shoots blighted. It therefore seems natural to infer that the appearance of these sucking bugs on the trees is of extreme importance, especially when conditions are favorable for the development of the fire blight; their presence on the diseased trees should increase the spread of the causal organism.

Without question the tarnished plant-bug is worthy of special consideration as a fire blight disease disseminator and also the species *Campylomma verbasci* is undoubtedly of particular importance. This is due to their great abundance in the nursery blocks and to the fact that their attacks are chiefly confined to the tips of the shoots. These two species are frequently found in great numbers, as many as ten or twelve having been observed on a single nursery tree. Where there has been sufficient rainfall and cultivation to cause a rapid and succulent growth of the trees, the presence of sucking bugs on diseased shoots affords conditions favorable for the wide dissemination of the bacteria.

On the other hand, it is to be noted that sucking bugs may be present in great numbers without the occurrence of much blight. This may be attributed to two factors: the absence of hold-over cankers to furnish a source for blight infections and, what is of more importance, the unfavorable condition of the trees for infections to occur. This was especially emphasized during the season of 1914. In one large nursery, throughout the months of July and August, there was abundant rainfall, causing the trees to make a rapid growth. Considerable blossom blight appeared in a large orchard nearby and on being spread to the young nursery stock, a severe outbreak of the disease occurred and thousands of trees were

destroyed. In another large nursery located in a different section of the state where the rainfall was extremely light, practically no blight was observed throughout the summer, although the conditions were in many respects the same as those in the other nursery. A large amount of blossom blight was present in adjoining orchard trees; the stock had received about the same amount of cultivation and sucking bugs were present in great numbers; but the long-continued drought checked the growth of the young shoots, causing them to be not only more resistant to the attacks of the blight bacteria, but also not so liable to injury by these insects.

Because of the seasonal variations in the numbers of sucking insects which are capable of spreading fire blight in the nursery blocks, it is impossible to say which of several species are of most importance in blight dissemination.

Practically no experimental data are at hand with reference to the spread of twig blight in orchard trees and the writers are of the opinion that this question is of special interest. Indications point to the fact that certain sucking insects disseminate the bacteria in the orchard, but this has not been definitely determined. The well known apple red-bugs, *Heterocordylus malinus* Reuter and *Lygidea mendax* Reuter, which often so seriously infest orchard trees⁵ are certainly able to spread the blight, as they puncture the tissue at the tips of the young twigs thus affording an entrance for the blight bacteria. From all indications the same species may also increase the amount of fruit blight which is sometimes common in certain varieties of apples. This may be particularly true where fruit blight is so abundant in the early part of the summer. Several specimens of fruit blight were received during the autumn of 1914 from various apple orchards in New York State and frequently the blighted apples showed red-bug injury. In the month of September, 1914, the writers visited a badly blighted Tolman Sweet apple tree which had been infested with red-bugs and a considerable portion of the fruit was blighted. Twig blight was abundant on the tree and many of the lesions were exuding the gummy substance characteristic of fire blight infections. There is some question as to whether red-bugs were responsible for the large amount of fruit blight as but few of these insects occur on trees after the latter part of July. On the other hand, undoubtedly other closely related species were present. These insects visiting the twigs, became smeared with the sticky ooze of the blight and carried the bacteria to the fruit, the organism gaining an entrance through the feeding punctures of the bugs.

⁵ Crosby, C. R. The apple red-bugs. New York (Cornell) Agr. Exp. Sta. Bul. 291: 211-225. 1911.

Of particular interest is the recent work by Parrott and Hodgkiss⁶ on the false tarnished plant-bug (*Lygus invitus* Say) as a pear pest. They report this insect, which is closely related to the tarnished plant-bug, as causing severe injury to the fruit of orchard pear trees. Doubtless the false tarnished plant-bug is capable of transmitting the blight bacteria and probably is of considerable importance in the spread of the disease. These writers also mention *Campylomma verbasci* Herrick-Schaeffer which is so common in the nursery, as also occurring on orchard pear trees. They report *Paracalocoris colon* Say, also closely related to the tarnished plant-bug, and the false red-bug, *Lygidea mendax* Reuter as feeding on the succulent growth of orchard pear trees.

Certain species of flies are attracted in considerable numbers to the gummy exudations of blighted trees and they, no doubt, carry the bacteria from place to place. It is possible that these flies may produce fire blight inoculations by injuring the tissue with their claws. However no experimental data are at hand to substantiate this point.

In view of the experimental work which has been done relative to the dissemination of fire blight bacteria in nursery stock, it seems desirable that similar studies be made on orchard trees in order to determine if possible, which agents are of most importance in the spread of this disease, particularly of twig blight.

Meanwhile cooperative experiments between pathologists and entomologists, which will lead to the control of these sucking bugs, should be encouraged by all interested in holding the disease in check. These species of insects, not only cause considerable injury to the trees, but from the nurserymen's standpoint, at least, the control of sucking insects would undoubtedly be a determining factor in reducing the annual losses caused by the fire blight disease.

DEPARTMENTS OF PLANT PATHOLOGY AND ENTOMOLOGY

CORNELL UNIVERSITY

ITHACA, NEW YORK

⁶ Parrott, P. J. and Hodgkiss, H. E. The false tarnished plant-bug as a pear pest. New York (Geneva) Agr. Exp. Sta. Bul. 363: 363-384. 1913.

NOTES ON THE DISTRIBUTION AND PREVALENCE OF THREE IMPORTANT SWEET POTATO DISEASES

L. L. HARTER

STEM ROT

In 1914, Harter and Field¹ published investigations on the sweet potato stem rot in which it was shown that this disease was caused by *Fusarium hyperoxysporum* Wr. and *F. batatas* Wr. It was pointed out among other things that the disease had been studied in plants collected in New Jersey, Delaware, Maryland, Virginia and Alabama, and the causal organisms isolated. Likewise attention was called to the fact that different pathologists had reported the disease in other states, and that these investigators, without apparently making a thorough study of the disease, had followed the conclusions of Halsted, who claimed *Nectria ipomoeae* to be the cause of the trouble. However, after it was shown that this fungus was not the true cause of the stem rot, the distribution of the disease as determined by the presence of *Nectria ipomoeae* on plants was questionable. Therefore to determine with certainty the distribution of this and other important sweet potato diseases, the writer personally visited a number of sweet potato growing sections in the different states during the fall of 1914. In addition to the states already mentioned, the disease was found in Ohio, Illinois, Missouri, Iowa, Kansas, Oklahoma, Arkansas, North Carolina, Georgia and Mississippi. From these data it is seen that the stem rot has already a wide range of distribution.

At Marietta, Ohio, and Cobden and Anna, Illinois, stem rot was found on the Yellow Jersey variety and the total loss was estimated at from 10 to 40 per cent. The farmers claimed that the disease was not known until seed potatoes had been imported from New Jersey, Delaware and Virginia. The disease was found at Sikeston, Missouri, but only to a limited extent, the loss to the crop not exceeding more than 5 per cent. At Muscatine, Iowa, the Yellow Jersey is the principal variety grown and in many fields 50 to 60 per cent of the plants were infected with stem rot. In fact, so destructive has the disease become to this variety that a whole crop is sometimes lost. It is interesting to note in this connection that the Southern Queen variety, growing beside the Yellow Jersey under identical conditions, was unaffected.

¹ Harter, L. L. and Field, Ethel C. The stem rot of the sweet potato (*Ipomoea batatas*). *Phytopath.* 4: 279-304, plates 14-16. 1914.

Stem rot was found at three points in Kansas, namely, Wamego, Manhattan and Herington. Sweet potatoes are grown only to a limited extent at Manhattan and Herington, but at Wamego this crop forms an important industry. The Yellow Jersey variety is the one most generally grown and in some fields the stem rot destroys as much as 60 per cent of the crop. In both Iowa and Kansas the farmers claimed that the disease had been introduced by means of seed imported from eastern states. At Oklahoma City stem rot was fairly common in the Yellow Jersey, Pumpkin Yam and Bradley Yam varieties. This being a new section for sweet potatoes, the loss was relatively small. At Fort Smith and Lincoln, Arkansas, stem rot was very common in the Nancy Hall and Yellow Jersey varieties. No cases of the disease were found in Yellow Yam, a variety grown very extensively in Arkansas, Texas and Oklahoma.

In North Carolina, Georgia, Alabama and Mississippi, the other states where stem rot was found, Yellow Jerseys are not grown, but Nancy Hall, a variety equally susceptible to the disease, is widely cultivated. In this variety the disease was found at Goldsboro, North Carolina, Savannah, Georgia, Hattiesburg, Mississippi, and at Foley, Bay Minette, and Axis, Alabama. Only in Alabama was the disease observed to be causing any great loss. In this region it destroyed 20 to 50 per cent of the Nancy Halls and was found prevalent in the Porto Rican and Providence varieties. No stem rot was found in the Triumph, a variety grown extensively in the same region.

Fusarium batatas was isolated from specimens collected at Foley, Alabama and at Savannah, Georgia, while at all other places *F. hyperoxysporum* was found to be the causal organism.

BLACK ROT

This disease caused by *Sphaeronema fimbriatum* (Ellis and Hals.) Sacc., has been found on specimens collected from many places in New Jersey, Delaware, Maryland and Virginia, at Marietta, Ohio, Cobden, Quincy, Epworth and Anna, Illinois; Sikeston, Missouri; Muscatine Iowa; Manhattan and Wamego, Kansas; Oklahoma City and Ada, Oklahoma; Fort Worth and Gainesville, Texas; Fort Smith, Lincoln and Little Rock, Arkansas; Goldsboro, Stacey, Salisbury and Newton, North Carolina; Savannah and Jesup, Georgia; Bay Minette, Axis, Madison and Foley, Alabama. The disease has therefore quite a wide range of distribution and it is probable that it occurs wherever sweet potatoes are grown. At many of these places the disease had caused heavy losses in the hotbeds and in the storage houses. In some instances the farmers regarded the black rot, as even more serious than the stem rot.

FOOT ROT

This comparatively new disease (*Plenodomus destruens* Harter) has been previously reported² from Virginia and Sikeston, Missouri. It was found again in considerable abundance during the fall of 1914 at Sikeston, Missouri, and for the first time at Muscatine, Iowa, and at Marietta, Ohio. From the losses caused by this disease it is not unlikely that it will become a real menace to the growing of the sweet potato crop. At Marietta, Ohio, 75 per cent of the plants in a field of General Grant Vineless were diseased. At Muscatine, Iowa, foot rot was more generally prevalent and caused, on the whole, more loss, although no fields were found with such a high percentage of infected plants as in Ohio. At Sikeston, Missouri, the total loss to the crop was small but individual plants were found in which the organism had grown down from the stem into the roots, forming fruiting bodies and partially decaying the tissue. A pure culture of *Plenodomus* was secured from decayed tissue within the potato. This organism was found to cause a serious hotbed trouble in Virginia during the spring of 1914, where it occurred in abundance on the young plants in the field taken from the hotbeds.

U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PLANT INDUSTRY

WASHINGTON, D. C.

² Harter, L. L. The foot rot of the sweet potato. Jour. Agr. Research 1: 251-273, plates 23-28. 1913.

PHYTOPATHOLOGICAL NOTES

Personals. Dr. P. J. Anderson, formerly Field Pathologist with the Pennsylvania Commission for the Investigation and Control of the Chestnut Blight Disease, has been appointed Instructor in Botany at the Massachusetts Agricultural College.

Dr. Otto Appel has accepted a temporary appointment in the Bureau of Chemistry of the United States Department of Agriculture, to advise regarding the industrial uses of potatoes.

Errata. The following errata were made in the article The Pathological Histology of the Endothia Canker of Chestnut in PHYTOPATHOLOGY, volume 4, June, 1914:

The description given under figure 2 should have appeared under figure 1; the description given under figure 3 should have appeared under figure 2; the description given under figure 1 should have appeared under figure 3.

Mordecai Cubitt Cooke. The death is announced of the veteran Mycologist, Doctor M. C. Cooke, which took place on November 12, 1914 at East Southsea, England, at the ripe age of nearly 90 years. Doctor Cooke was born at Horning, Norfolk, England on July 12, 1825. A biographical sketch will appear in the first number of our Journal for 1916.

REPORT OF THE SIXTH ANNUAL MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

The sixth annual meeting of the Society was held in the Medical Building of the University of Pennsylvania, Philadelphia, Pennsylvania, December 29, 1914, to January 1, 1915, in connection with the American Association for the Advancement of Science.

About ninety-five members were present and a program of fifty-eight papers was presented. The abstracts of these papers were published in the December number of PHYTOPATHOLOGY. Several new members were elected making a total of 293.

Joint sessions were held with Section G of the American Association for the Advancement of Science and with the Botanical Society of America.

The following officers were elected for 1915:

President, H. H. Whetzel, Cornell University, Ithaca, N. Y.

Vice-President, W. A. Orton, U. S. Department of Agriculture, Washington, D. C.

Councilor for three years, Mel T. Cook, New Brunswick, N. J.

Editorial Board, Donald Reddick was elected chairman of the Board of Editors for three years.

The following associate editors were elected for three years: H. W. Barre, E. A. Bessey, H. R. Fulton, W. T. Horne.

C. L. Shear was elected business manager for the coming year.

The Society decided to hold its next annual meeting at Columbus, Ohio, in connection with the meeting of the American Association for the Advancement of Science. The Society also voted to hold a special meeting at San Francisco, California, August 2 to 7, in connection with the meeting of the American Association, and the secretary was instructed to arrange with the secretary of the Western Branch of the Society the necessary details in connection with the program.

The following recommendation in regard to the attendance of the secretary at the special meeting was adopted:

"In view of the present state of the treasury and the unusually heavy traveling expenses involved, we do not now authorize the attendance of our secretary at the San Francisco meeting at the Society's expense.

"This action is not to be construed as restricting the freedom of the Council to authorize this journey if unforeseen conditions make it urgently important."

REPORTS OF COMMITTEES

The Committee on Affiliation and Relation to other Societies presented the following report which was accepted and the Committee discharged:

Appreciating highly the cordial spirit shown in the proposition of the Committee on Affiliation of the Botanical Society of America, and the courteous manner in which this has been presented, we reply as follows: In view of certain financial and other obligations resting upon this Society we consider it inexpedient to urge further affiliation of the two societies at present.

We trust, however, that this may not be construed as indicating any unwillingness on the part of the American Phytopathological Society to give further consideration to this question.

F. C. STEWART,
C. L. SHEAR,
Committee

The Committee on Common Names of Plant Diseases presented a report suggesting ten rules to be followed in the preparation of a list of common names of plant diseases. The Committee also recommended that the Society appoint a permanent committee of five on common and scientific names.

The Society voted that the important progress represented by the report of the Committee be recognized and that the Committee be continued and requested to submit a copy of its recommendations to each member of the Society for suggestion and criticism.

The Committee on Ways and Means, consisting of F. C. Stewart, C. L. Shear, Donald Reddick, H. H. Whetzel, and C. E. Bessey, made the following report, which was adopted and the Committee continued:

The Committee has tried to interest certain wealthy persons in providing an endowment for PHYTOPATHOLOGY, but, so far, has failed. However, the first \$50 towards a permanent fund has been contributed by Dr. W. G. Farlow. It is recommended that the Secretary be instructed to thank Dr. Farlow for this gift.

It also recommends that the Society proceed to incorporate under the laws of the District of Columbia.

Upon motion, the Society authorized the secretary-treasurer to select the two other persons necessary and to proceed to secure articles of incorporation for the Society under the laws of the District of Columbia.

The Committee on Ways and Means was empowered to appoint a sub-committee to confer with Dr. Flexner, of the Rockefeller Institute for Medical Research, regarding plans for the promotion of phytopathology. L. R. Jones was appointed chairman of such sub-committee, with power to select his associates.

The report of the Committee on Bibliography was presented by the chairman, L. R. Jones. The results of the Committee's efforts are to be found in the lists of literature now appearing regularly in PHYTOPATHOLOGY. Great credit is due Miss E. R. Oberly, Librarian of the Bureau of Plant Industry, and the Chief of the Bureau of Plant Industry, Dr. W. A. Taylor, for their approval and assistance in this undertaking. The Committee was continued with instructions to consider the feasibility of issuing the list on cards for sale at cost.

Donald Reddick, chairman of the Committee on Business Arrangement with Williams and Wilkins Company, publishers of PHYTOPATHOLOGY, reported that the present contract with the company was very satisfactory with the exception that the returns from advertising had not reached the expectations of the Company and the guarantee should be reduced from \$240 to \$150 for the coming year. It was recommended that the present arrangement with Williams and Wilkins Company, with this modification, be approved for the coming year. The report and recommendations were adopted.

The Committee consisting of G. G. Hedgecock, N. J. Giddings, and N. E. Stevens, appointed to audit the treasurer's account, reported that the accounts had been examined and found to be correct, and the report was adopted.

The treasurer's report was as follows:

TREASURER'S REPORT

Receipts

Cash on hand in bank January 1, 1914.....	\$454.32	
Interest on bank deposits, January 1 to December 1.....	15.49	
5 vols. and 1 no. PHYTOPATHOLOGY.....	15.50	
266 members' dues, 1914.....	798.00	
Back dues, 1913.....	3.00	
Exchange on checks and sale of membership lists.....	1.24	
Cash contribution from Dr. Farlow for PHYTOPATHOLOGY.....	50.00	\$1337.55

Disbursements

Printing, postage, expressage, etc.....	23.74	
300 separates of abstracts, Atlanta meeting.....	35.00	
Clerical assistance.....	20.25	
Williams and Wilkins, 5 vols. and 1 no. PHYTOPATHOLOGY.....	15.50	
To 367 members, subscriptions of PHYTOPATHOLOGY..	734.00	828.49
Balance on hand.....		\$509.06

The financial statement of the business manager of PHYTOPATHOLOGY, Donald Reddick, was presented and referred to an auditing committee consisting of H. R. Fulton and F. C. Stewart, which examined and approved the accounts. A small deficit was shown when the December bills which were unpaid were deducted.

RESOLUTIONS

The Society received greetings by telegraph from the newly organized Western Branch, meeting at Corvallis, Oregon. The following resolution was presented and adopted:

The Council recommends that the Society extend cordial greetings to the newly organized Western Branch of the American Phytopathological Society. It also recommends that a committee consisting of the present president, Haven Metcalf, and the secretary, with power to increase their number to five, be authorized to formulate the necessary terms of affiliation to provide for this and any other future branches which may be organized.

WHEREAS, it is known that a serious disease-producing parasite (*Urophlyctis alfalfae*) occurs in certain sections of Europe and this country and is liable, unless checked, to spread in the near future to other sections to the permanent injury of this highly valuable crop, and

WHEREAS, the plant pathologists or other officials of the individual states are unable properly to meet the situation, partly from lack of information, partly because it is essentially an international and interstate problem, be it therefore

Resolved, that we respectfully invite the attention of the Honorable Secretary of Agriculture and other officials of the U. S. Department of Agriculture to the above facts and urge the importance of immediate and earnest investigation under their leadership as to the present occurrence and seriousness of the disease, as to its means of distribution and as to what steps, if any, should be taken to check its further spread.

Resolved, the American phytopathologists greatly appreciate the importance of Schweinitz' collection of fungi now in the possession of the Philadelphia Academy

of Natural Science, it being the earliest large American collection. All botanists are interested in its preservation and especially those doing monographic work on fungi.

It is recommended that a committee of three be appointed by the Chair to confer with the Academy with reference to any steps that may be desirable to thoroughly insure the permanent preservation of the collection.

C. L. Shear, J. C. Arthur, and A. G. Johnson were appointed.

Resolved, that The American Phytopathological Society records its pleasure at the opportunity of becoming personally acquainted with Dr. Otto Appel and its satisfaction with the outcome of this first formal attempt to establish closer international phytopathological relations. We wish hereby to express our appreciation of the courtesy and scientific spirit in which Dr. Appel has coöperated in the consideration of our problems, and express our hope that this is but the first of such undertakings by the U. S. Department of Agriculture.

Resolved, that the Society express its deep appreciation of the efficient and faithful service of the retiring chairman of the Board of Editors, Prof. L. R. Jones, and that it also express its confidence in its new editor, Dr. Donald Reddick, and assure him of its active support.

MOTIONS

Upon motion, all the acts of the Council as reported to the Society were approved and adopted.

Moved, that the second paragraph under Editorial Notices on the inside cover of PHYTOPATHOLOGY be changed to read as follows:

"Manuscripts should be typewritten and carefully revised before submission. While no attempt will be made at exact uniformity in capitalization, punctuation, spelling, citations, footnotes, etc., each contributor is requested to give careful attention to clearness and preciseness in these matters and to conform as far as practicable to the best usage in this JOURNAL."

Moved, that a committee of three be appointed by the Chair to confer with Professor Farlow, and, in its discretion, with any other persons concerned, to express the sentiment of the Society that the continued delay in the publication of the Bibliographical Index of North American Fungi is a distinct loss to science and particularly disadvantageous to plant pathology, and to ascertain if anything can be done to remove existing obstacles and to facilitate its early publication.

Dr. C. E. Bessey was appointed chairman of the Committee with power to select his associates.

H. S. Reed called the attention of the Society to the desirability of institutional standardization with reference to plant pathology. Upon motion the president was directed to appoint a committee to consider this matter.

H. S. Reed, H. H. Whetzel and H. R. Fulton were appointed.

A contribution of \$25 toward the Millardet Memorial at Bordeaux, recommended by the Council, was withdrawn, as it was learned that the memorial had already been completed and paid for.

It was voted to increase the price of back volumes of PHYTOPATHOLOGY to \$4 after July 1, 1915. It is hoped that all the members and others wishing to fill out sets will take advantage of this opportunity and purchase before the price is increased.

On recommendation of the Council the Society voted to appropriate \$200, or as much thereof as needed from the funds of the Society, toward the expenses of PHYTOPATHOLOGY, during the year 1915.

The following constitutional amendment proposed at the last meeting was adopted:

Article 3, section 3, shall be changed to read, "Any person may become a patron upon the payment of \$100."

The Society passed a unanimous vote of thanks to the Local Committee for the excellent facilities and courtesies offered the Society during the meeting and to Dr. F. D. Heald for the care of the exhibits and other assistance in promoting the success of the meeting, also to the Chair for conducting the meetings with promptness and carrying the program through on time.

The method of presenting papers by abstract introduced at the Atlanta meeting was continued, with slight modifications, at the Philadelphia meeting, with great success. Six minutes were allowed for the presentation of each paper, the author being permitted to read the abstract as printed or use the allotted time in giving additional explanation or presentation of the topic, after which five minutes were allowed for discussion. The same method of handling the program was adopted for the future and the secretary authorized to limit the time for the acceptance of titles and abstracts, and to accept no titles for the program which are not included in the printed abstracts. Abstracts should be restricted to 200 words and must be in the hands of the secretary by December 1 in order that they may be published in the December issue of PHYTOPATHOLOGY.

C. L. SHEAR,
Secretary-Treasurer

[PHYTOPATHOLOGY, for February, 1915 (1: 1-82, Pls. I-VII), was issued February 15, 1915.]

PHYTOPATHOLOGY

VOLUME V

NUMBER 3

JUNE, 1915

INTERNATIONAL PHYTOPATHOLOGIC COLLABORATION

WORK BEGUN IN EUROPE—WILL IT BE PROSECUTED IN AMERICA?

JAKOB ERIKSSON

THE BEARING OF THE QUESTION

During the last twenty-five years we have seen in Europe an endeavor to bring together the phytopathologists of different countries to a systematic collaboration for combating the diseases of cultivated plants.

This idea is based on the fact, now, as I think, uncontested, that not only the growers but also the men of science are in most cases puzzled as to how to act against the parasites of different kinds, which now and then menace the culture of plants. Why this annoying state of things? The answer to this question is that our impotence against these enemies is due chiefly to serious deficiencies in our knowledge of the nature of the destroyers.

In a few cases only, do we really know the nature of these so well, that we may found on this knowledge an effective control of the diseases. Such is the case with the smuts (*Tilletia* and *Ustilago*) on the cereals, parasites that we know well enough to be able somewhat to control.

But in how many other cases is this true?

The common potato disease (*Phytophthora infestans*), known in Europe and in North America since about the year 1845, has been diligently and repeatedly studied on both continents. In spite of all efforts the parasite has spread to all countries where potatoes are cultivated, at last (1904) to Australia. It is true that we have learned that the spraying of the potato field with fungicides is an effective method of restricting the destructive effects of the fungus. Further we profit by the fact that varieties of potatoes differ in their susceptibility to attack by the parasite. But we are not advanced any further. We are yet incapable of preventing an outbreak of the disease or of stopping the spread of it. In spite

of all researches, even the latest, the wintering of the fungus from year to year is yet an unsolved problem.

The grain rusts (*Puccinia graminis*, etc.) are known from ancient time as causing very destructive epidemics in all corn growing countries. By new and profound studies our knowledge of the nature of the parasites is extended, especially in reference to their polymorphism and to their spread by means of infected seed. No unanimous conception of the results however has been acquired and consequently no commonly accepted basis given for extensive practical efforts to combat the diseases. Last year our hopes lay in one of the great European states, that seemed inclined to start a new profound investigation on the grain rusts. Unfortunately the great war began, overthrowing all these plans.

The gooseberry mildew (*Sphaerotheca mors-uvae*) is a new disease to Europe. The first appearance of the parasite in Europe (Ireland, Denmark) was reported in the year 1900. In the course of ten years it occurred in all the European countries in which goosberries are cultivated. As a consequence of this the authorities were driven to the necessity of taking their refuge in legislative measures. Quarantines were established against the transportation of gooseberry plants within the countries as well as against the importation of foreign gooseberry plants and fruits. Arrangements for inspection and control of infected gardens were made, and especially in England, a vast and expensive service was organized. The cultivators tried spraying with liquid fungicides. Unfortunately it had escaped the memory or the attention of the authorities and of the scientists, that there are important blanks in our knowledge of the biology of the parasite. The life-history of the fungus had not been followed throughout the whole year. The germination of the ascospores and the infection by means of these spores are as yet not cleared up. The occasional, sudden outbreak of the disease in the height of summer (July) is also unexplained. If all these questions had been clear at the time of the immigration of the pest into Europe, great sums spent on fruitless labor would have been spared; and by the employment of effective means gooseberry culture—the most important berry-culture of North and Middle Europe—would have been saved from a seriously impending ruin.

LOSSES CALCULATED

In different countries calculations have been made of the losses caused by the diseases of cultivated plants. Astounding figures have resulted. Through the grain-rusts, Germany lost in the year of 1891 about \$100,000,000 and the United States of North America, through the rust of wheat, about \$67,000,000. The yearly loss caused to the world crop by the

grain-rusts is estimated at about \$250,000,000. The annual loss of the United States of North America through the potato blight is estimated at about \$36,000,000 and so on. The powdery mildew of the grape (*Oidium Tuckeri*) at first noticed in Europe (England), about 1845, is said to have reached every European vineyard before 1851. The downy mildew of the grape (*Plasmopara viticola*) made its first appearance in Europe in 1870 and within ten years reached all grape-growing countries of that continent. In 1895, this parasite caused in Hungary a loss of about 12,000,000 of hectolitres of wine. The annual loss caused by the diseases to the grape crop of the whole world is estimated at about \$2,500,000,000.

THE QUESTION BEFORE CONGRESSES

The idea of an international collaboration in order to control the most destructive diseases of cultivated plants was made public for the first time, in Vienna in 1890. Later the same question was presented to international meetings: 1900 in Paris; 1903, 1905 and 1907 in Rome; 1907 in Vienna; 1908 in Montpellier; 1909 and 1910 in Rome; 1912 in Paris; 1913 and 1914 in Rome.

All these conferences have insisted on the need of genuine collaboration between the pathologists of the different countries in order to acquire a fuller knowledge as to the nature and the evolution of the parasites, with a view of finding out new methods for combating the enemies.

ROME AS CENTRE OF THE COLLABORATION

The establishment of the International Institute of Agriculture at Rome being decided, thoughts were turned towards this Institute as the centre of the collaboration. Plans for the organization of the work according to these ideas were presented to several general assemblies of the Institute. At first the Institute took a fairly adverse position on the question, which was out of its program. The prerequisites for the realization of the plans—especially money and staffs—were lacking. But gradually the position of the Institute towards the question grew more favorable, especially from the time of the International Pathological Congress at Paris in 1912. This Congress pronounced itself in favor of it. The consequence of this turning was a request addressed by the General Assembly at Rome in 1913, to the French Government to invite all contributing states of the Institute to an International Phytopathological Conference at Rome. Such a Conference was held there in 1914 from February 25 to March 4. At that Conference were present 59 delegates from 31 states, of which 20 were European and 11 extra-European.

INTERNATIONAL PHYTOPATHOLOGICAL CONVENTION

The chief aim of the Conference was to organize an International Phytopathological Convention, acceptable to all states. This Convention should establish the principles for the organization of a Phytopathological service in different countries. After a long deliberation an *Acte final de la Conference Internationale de Phytopathologie, fait à Rome le 4 Mars 1914*, was accepted by the delegates. This act which contained twenty-one different articles, with forms of certificates, was to be submitted to the governments of the different states for consideration and approval.

It must be admitted freely that through the decisions of this Conference the question of an international collaboration in order to combat the diseases of plants is in some degree solved. By an official professional inspection and control the principles are fixed for preventing, as far as possible, the spread of dangerous diseases from culture to culture, from land to land.

SCIENTIFIC RESEARCHES NOT ADVANCED

However the struggle against the diseases of plants comprehends much more than inspection and control. There is also another matter—and this I think very important—that is the gaining of more effective means for combating the diseases. For reaching of such means no inspection or control legislation will help. The only way to that end is continued research and continued experiments, in other words, a strengthening and development of scientific pathological work.

In a series of papers I have, since 1890, at several international congresses, drawn attention to this fact. Of late I have done it by the report *Les problèmes phytopathologiques. Les différences des maladies exigent des mesures différentes*, presented to Conference at Rome in 1914.

From a careful consideration it will be obvious that this side of the phytopathological question is by no means forwarded through the arrangements made in Europe hitherto. Rather a regression of phytopathological research is to be feared. In several states, where a phytopathological service has been introduced, for instance in Holland and in Italy, this service is located at existing experimental stations. The original and specific task of those stations, investigation and experimentation, must by this arrangement be seriously hindered. Misgivings in that direction are also expressed from different countries. Such being the case, I took the liberty, after having conferred with several colleagues, at the final session of the Conference, to say an open word of warning against the danger here threatening. The want is not supplied by enlarged staffs and increased grants to those stations. The phytopathological inspection

service is of a regulatory character, and ought to be organized separately and placed under administrative authority. The services of the scientific experimental workers may not be required, except in unusual cases, that is, if the competency of the service is insufficient.

THE GREAT WAR AND THE FUTURE OF THE COLLABORATION IN EUROPE

The continuation of an international phytopathological collaboration in Europe is rendered impossible, I think, for a long time to come through the great war that broke out last year. The harmony between the nations of Europe is now so deranged that the reestablishment of peace will probably not be able to heal the wounds. The common work is doomed in Europe, certainly for decades.

NORTH AMERICA IN THE PLACE OF EUROPE

Shall this work cease? I do not believe it. There is a continent greater than all the states of Europe combined, which is out of the war. This continent has the most varying natural conditions and kinds of soil and has at its disposal all the resources of money and of scientists required for undertaking the work. That land is the great continent of North America, in the first place the United States.

Judging from remarkable utterances made by professionals of distinction in the American press, the soil seems to be well prepared and suitable for the transportation of the tender, languishing plant of collaboration from European to American ground. Numerous articles by American phytopathologists for the last decennium give evidence of a more and more awakened interest in phytopathological research.

If the United States of North America is willing to take the initiative and the charge of an organized collaboration against the diseases of our cultivated plants, that now cause colossal losses to all countries of the world, they will further vindicate their place of rank in the science and they will deserve well of the gratitude of all mankind.

STOCKHOLM

SWEDEN

EUROPEAN LITERATURE

1890-1914

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LEAF ROLL DISEASES OF THE POTATO¹

D R. O. A P P E L

The importance of the potato as a cultural crop has led many phytopathologists to devote their attention to the diseases of this plant. Many of the problems involved are complex and much remains to be done before a satisfactory solution is reached, but the progress so far made is such as to justify our presenting a résumé of what has been accomplished and calling attention to the problems which it is highly desirable to solve.

All potato diseases can not, of course, be discussed in a single lecture, consequently I will restrict my remarks to the group which seems to me the most interesting, that is the group which is characterized by a rolling of the leaves.

From the literature on the subject you know that in former years tremendous epidemics occurred among potatoes, the cause of which was assumed to be the disease called "curly dwarf." Examination of the extensive literature concerning these epidemics shows that the numerous descriptions of the disease are by no means concordant, and therefore there is hardly any doubt that the different authors were concerned with different diseases. I have tried to bring some order out of this chaos by dividing the "curly dwarf" of the old literature into three types, which I have designated as the curly dwarf (in a more restricted sense), the leaf roll disease, and the bacterial ring disease. I have at the same time pointed out that in all probability another division of the leaf roll disease would be necessary, and this has actually proved to be the case, for it has developed that the disease which I originally designated as the leaf roll disease was in reality a combination of several diseases.

Investigation of the cause of the leaf-roll symptoms shows that it is a disturbance of the water balance of the plant. If a plant transpires more water than can be supplied, as often happens during very hot days, it wilts. If transpiration constantly exceeds absorption to some degree the leaves do not expand fully, but fold parallel to their longitudinal axis so that either the two halves of the leaf finally lie against one another or the leaf margins roll in toward the midrib. Such a rolling may be caused by various influences, such as external conditions which affect the root system, internal conditions which influence the chemical composition of the

¹ A lecture delivered at the Universities of Iowa, Minnesota, Wisconsin and Cornell.

plant, or the disorganization of the vascular system. Parasites also may have a pernicious influence on the water balance by living in the vessels, thus distorting the normal transport of water and nutrient substances, or they destroy the tissues completely.

As the symptoms of diseases differ so do their causes, and from external symptoms it is often difficult to determine the disease with which we have to deal. It should never be forgotten, however, that a sure diagnosis can be made only on the basis of thorough investigation.

Let us now consider the different aspects of the diseases, beginning with the true curly dwarf (Kräuselkrankheit), which name I use to designate all diseases of the vine that show shortened internodes and curly leaves. The curly appearance is caused by a shortening of the midribs. The leaf lamina is larger than the space between the different ribs, consequently the leaf becomes undulate. The stems of such plants are exceedingly brittle and very often the leaves remain small. When the disease is very distinct the plants remind us of winter cabbage.

Potato vines affected with curly dwarf give small yields and produce small tubers. The next year these tubers produce diseased vines. In most cases no normal tubers are produced by these vines and consequently are not used for seed purposes, which fact prevents wide dissemination of the disease. Curly dwarf has never been widespread and I have not found an epidemic of the disease the last fifteen years, and likewise in the United States I have found it occurring only sporadically. It is only within the limits of experiments with certain varieties that occasionally all vines are diseased. Sometimes plant breeders find distinct varieties completely affected, but these are eliminated and never find their way into agriculture.

The disease called "streak" in America is in some respects similar to curly dwarf. The symptoms of the disease are black streaks on the stems and leaf nerves, which are frequently accompanied by black spots on the leaves. As early as 1897 Frank described this disease, designating it under the collective name of "vine diseases" (Staudenkrankheiten). In my work entitled *Die Blattrollkrankheit und unsere Kartoffelernten*, published in collaboration with my assistant Dr. Schlumberger, I have shown that the vine disease of Frank includes curly dwarf as well as streak and that it is also a combination of these two diseases.

The streak disease seems to be of bacterial origin, but so far its real cause has not been discovered. In cases where it is but weakly developed it does not resemble curly dwarf, but sometimes the internodes are shortened and the leaves curled, and in these it is always apparent that the black streaks and the curling and dwarfed appearance are due to the same cause. These injuries cause a decrease in the yield, but whether the disease is transmitted through the seed has not been proved. The

trouble is pretty common in the United States and it would be a good thing to investigate it.

The next disease about which I wish to speak is leaf-roll. In this disease the rolling of the leaves is most distinct and is one of its most reliable diagnostic characters. This phenomenon consists in the upward and inward rolling, more or less parallel to the midrib, of the individual leaflets. Sometimes this rolling is more pronounced at the base of the leaflet, the result in such case being a somewhat funnel-shaped structure. No undulation of the leaf surface or of the leaf margin accompanies this rolling. In seriously diseased or inadequately nourished plants the rolling occurs especially early and is very pronounced, while in plants less seriously affected or well nourished it is slow to make its appearance. Coincident with the rolling a discoloration, which may be either yellowish green or reddish, depending on the variety of potato, frequently develops. In some varieties the discoloration is almost violet. The intensity of the discoloration varies in different years, but appears to be more pronounced in dry years than in wet ones.

A further characteristic of seriously diseased plants is the peculiar manner of growth. In such plants the vines are shorter and the leaves assume a more erect position, and consequently before flowering have a more rigid appearance than similar healthy plants. Here again, however, the individual varieties differ. Another diagnostic character of diseased plants is the smallness of the flowers, leaves, and berries as compared with those of healthy plants.

In the case of seriously diseased plants there is frequently little or no tuber production. Such plants show either a very poor development with no tubers and die early or a good development of vines, which remain green until toward the end of the vegetative period, but which usually produce only very small tubers, the latter developing on foreshortened stolons or even directly on the subterranean stem end. The latter characteristic, however, is not constant, as frequently plants occur with normally developed stolons which bear a number of tubers of the most varying size. Although slightly affected plants may produce a large yield the plants grown from such tubers are certain to give only a very small yield.

Longevity of the seed tubers is characteristic of the disease. In many cases, though not in all, the diseased seed tubers remain alive until the crop is harvested. When such tubers are found the case is suspicious. One of the most distinct peculiarities of the disease is its inheritance, if I may so call it, by the seed potato, which in turn produces diseased plants. The inheritance through the seed has often been observed. In severe cases of the disease the symptoms are very distinct and the diagnosis consequently easy, but in many cases, such for instance as normal-

sized vines where the plants are characterized only by the rolling of the leaves, it is very difficult to recognize the leaf roll as such. With a little training, however, leaf roll may be distinguished from other diseases. Besides external symptoms it has an anatomical characteristic. Quanjer² has found that the phloem of the diseased plant is different from that of the healthy one, being pressed together and having an abnormal structure. For diagnostic purposes, however, this symptom should be used with precaution, for Schander³ discovered similar peculiarities in normal but old plants. The vessels do not show any change of structure.

The phases of sprouting of diseased tubers are peculiar. The digestion of reserve food materials in the diseased tubers is a much slower process than in healthy potatoes. It is possible that this depends upon a quantitative difference of the enzymes, but the investigations published up to this time have not thrown sufficient light on this question.

Necrosis of the phloem and change in the enzymes may be the cause of the external symptoms, but these are not the cause of the disease itself. The cause has not yet been found, but it is clear that the mycelium of *Fusarium*, which often occurs in the tissues, has nothing whatever to do with it. Climatic and soil conditions influence the intensity of the disease, but can not be its cause, although there are localities which evidently favor it.

The opinion of Hedlund⁴ that the leaf roll is a diseased mutation has some plausibility, but is only an attempt at explication and is not supported by any proofs. The sudden and general appearance of the disease can not be explained in this way.

The disease is of great economic importance as it seriously reduces the yields. In Colorado, for instance, it reduced the crop from some fields to one-fourth what it should be. In the western part of Germany this disease has been of much importance, but by means of field inspection it has been practically overcome, so that now it has no influence on the total crop of the Empire. I will discuss this field inspection and seed certification later on.

Other diseases of this group which might be mistaken for the leaf roll are the so-called "vascular mycoses." As already stated, the rolling of leaves is the result of disturbance in the water balance. So far as known,

² Quanjer, H. M. Die Nekrose des Phloëms der Kartoffelpflanze als Ursache der Blattrollkrankheit. Mededeelingen, Rijks Hoogere Land-, Tuin- en Boschbouwschool, Deel VI, 1913.

³ Schander, R., und von Tiessenhausen, M. Kann man die Phloëmnekrose als Ursache oder Symptom der Blattrollkrankheit der Kartoffel ansehen. Mitteilungen des Kaiser Wilhelm Instituts für Landwirtschaft in Bromberg, 6: 115. 1914.

⁴ Hedlund, T. Nagra Jakttagelser öfver bladrollsjuka hospotatis. Tidskrift för Landtmän, 31 Sta. Arg., 1910.

the disturbance in this case is caused by fungi of the genera *Fusarium* and *Verticillium*. As these diseases also produce a rolling of the leaves I did not at first distinguish them from leaf roll and I described the leaf roll as being of a parasitic character. Only later on was it proved that two diseases, one of a parasitic and the other of a non-parasitic nature, existed under the name of leaf roll. The early diagnosis of leaf roll disease includes the symptoms of both.

In the non-parasitic leaf roll there is no fungus in the wood vessels and no discoloration. In the parasitic leaf roll, tubers in which there is no fungus mycelium do not transmit the disease.

I wish to eliminate the name of leaf roll disease for the parasitic troubles and substitute the name vascular mycosis. The Austrian pathologists Kornauth, Köch, Himmelbauer, et al., adhere to the former term for these troubles and this must be borne in mind in dealing with Austrian literature on the subject.

The wilt disease described by Erwin F. Smith and D. B. Swingle may be taken as a prototype of the vascular mycoses. This wilt is widespread in the United States. On my trip I found it in every state visited. In some fields as high as 70 to 80 per cent of the plants were affected, something which I had never witnessed before. The disease occurs in Germany also, but is of much less importance.

There is some difference between the rolling of the leaves due to leaf roll and that due to *Fusarium* wilt. In the latter case only the upper leaves are rolled at the beginning. In light cases or when the air is damp the wilt is often indistinct, but the diseased shoots die off before the healthy ones. In very serious cases or in very hot weather wilt of the infected sprouts is most pronounced. In the case of mycosis, in contrast with the non-parasitic leaf roll disease, single vines may become affected while others remain healthy.

An infallible proof of the presence or absence of the disease is furnished by a cross section of the stem. In diseased plants the vascular bundles are more or less brown, and microscopic examination shows the mycelium in the secondary pitted vessels. From the vessels of the stem, into which the fungus probably gained entrance through wounds, the fungus passes to the vessels of the stolons and tubers. Not all tubers of a diseased plant necessarily become infected. In the case of the tubers the fungus occurs first at the stem end. In spring the mycelium extends to the eyes and later enters the vessels of the young shoots. In Germany similar diseases occur, but so far it has not been certainly determined what species of *Fusarium* cause them. *Verticillium albo-atrum* causes a similar disease. It is possible that the roll disease even in the United States may not be due exclusively to *Fusarium oxysporum*, and I also suspect that other organisms may produce symptoms similar to those of the wilt disease.

For the United States vascular mycosis has a peculiar significance in that it seems to be especially prevalent in irrigated districts. In Germany I have observed that it is much more prevalent in dry years and dry localities than in years and regions well supplied with moisture, and from this I conclude that its prevalence in irrigated localities is intimately associated with the irrigation. A study of the best methods of supplying water, it seems to me, therefore, is not only of general interest, but is also of vast importance.

As in the case of fungi, bacteria can also invade the vessels and cause the disease which has been described as bacterial ring disease, and in which a rolling of the leaves may sometimes occur.

Whether such a vascular disease is produced by a single bacterial species has not yet been established. Similar diseases have been described by various workers. One especially worthy of mention is a disease recently described by Spieckermann and Kotthoff.⁵ They have isolated a species named *Bacterium sepedonicum*, which grows very slowly, but on the other hand retains its pathogenicity in pure cultures for a long time. This disease is characterized by the spiral vessels being filled with a great number of bacteria while the pitted vessels are free or very slightly infected, and also by the large root vessels being for the most part free from bacteria and consequently interference with the water supply is not so great as in the case of mycosis. Gradually the enzymes secreted by the bacteria dissolve the walls of the spiral vessels and disorganize the surrounding parenchyma, and this results in softened places, which later give rise to cavities.

As the bacteria penetrate the tuber vessels from the vessels of the stem the disease is transmitted by the seed potatoes. In severe cases no shoots are produced, and as a result hills are missing or only sickly shoots, with longitudinally rolled leaves, develop. In less severe cases plants which appear normal are produced, but in the autumn these are paler and show a slight rolling of the leaves.

The disease is also influenced by the weather. A long period of drought results in a slow growth of the vines, the rolling appears earlier and is more noticeable, and the leaves become dry, beginning at the margin. This drying distinguishes the bacteriosis from the non-parasitic leaf roll disease, in which latter it does not occur.

⁵ Spieckermann, A. Zur Kenntniss der in Deutschland ampfenden Gefässkrankheiten der Kartoffelpflanze. Illustrierte Landwirthschaftliche Zeitung, 33: 680-682. 1913.

— Untersuchungen über die Kartoffelpflanze und ihre Krankheiten. 1. Die Bakterienringfäule der Kartoffelpflanze; In Gemeinschaft mit P. Kotthoff, Landwirtschaftliche Jahrbücher, 63: 659-732. 1914.

The signs of the disease are not so pronounced in long-continued wet weather. In slightly diseased plants they are seldom or not at all noticeable. The dying of the vines is an indication of the disease. As ordinarily the different shoots of the same plant are attacked in varying degrees of severity they do not all die at once. An examination of such suspicious vines is the only means of determining with certainty whether the plant is diseased.

Seed potatoes in many cases show dark spots in the vascular ring. Sometimes, however, the diseased tissues are not at all or only slightly discolored, but the softening of the diseased area is characteristic.

Another group of diseases characterized by leaf roll is that of the so-called "foot-disease." I separate these also into mycoses and bacterioses. The prototype of the former is the *Rhizoctonia* disease and that of the latter the black-leg disease. Both mycoses and bacterioses attack the subterranean parts of the stem, which prevents an adequate transfer of water and nutrients and finally causes the death of the aerial portions. In mycoses this process is relatively slow, but in bacterioses it is comparatively rapid.

Rhizoctonia solani, regarding which we have the investigations of Rolfs and Morse, often attacks the potato seedlings and frequently destroys such large areas of tissue that the entire seedling, or at least its upper portion, dies. In the latter case side shoots develop, and even in older plants the early attack is indicated by the peculiar method of underground branching. Frequently infected vines also remain shorter, the internodes of the terminal portion of the axis being much shortened. The upper leaves are more or less rolled, and frequently more or less red or yellow, but it is seldom that all the leaves show rolling. The disease converts the lower part of the stem into a punky, brittle mass, and as the trouble progresses the tissues die and the shoot withers.

In the case of the foot diseases, infection of the tubers does not as a rule take place, but the mycelium and sclerotia of the fungus are frequently found on the surface of the tubers. I do not believe the killing of the fungus on the surface of the tubers a very promising means of controlling the disease. The mycelium and sclerotia of the fungus may indeed be killed by means of a solution of mercury bichloride, but the fungus is so generally distributed in the soil that this treatment by no means protects the potato from the disease. It seems to me, therefore, that it is necessary to investigate the biology of the fungus and to study more carefully all its relations to the soil.

In Germany I once observed a severe attack of *Rhizoctonia* on new unbroken forest soil. As the soil had a strong acid reaction I attempted to suppress the fungus by treating the soil with lime, and in this I was en-

tirely successful. It seems, however, that the acid is not the factor favorable to the development of the fungus, for in artificial media the parasite grows better on alkaline than on acid media. I suspect that the large air content of the freshly broken soil was the real cause of the unusually good development of the fungus in this case. Similar conditions also exist in Maine and in the Stockton delta of California, but in California it is not on the forest but on the peat soil, which is also porous and well aerated, that *Rhizoctonia* appears. That the fungus requires a large amount of air is evidenced by the fact that in artificial media it grows only at the surface, and also by the fact that the cultures when flooded with hydrogen peroxide rapidly absorb oxygen. Furthermore the fact that it actively attacks cellulose adapts it for growth on forest and peat soils. On filter paper moistened with a nutrient solution it grows so actively that in a short time the paper disappears and the culture loses over 80 per cent in dry weight. These latter facts require further elaboration, but they are offered here in support of my assumption. It is still an open question whether all foot mycoses are caused by *Rhizoctonia*. Notwithstanding the abundance of this fungus it is not improbable that fungi other than *Rhizoctonia* may attack the potato plant in a similar manner.

Bacteria, like fungi, may cause foot disease, as they also live in the soil and enter the stem through wounds. While fungi can penetrate the cell wall, bacteria are able to dissolve the middle lamella, which causes the stems to become soft and in many cases black. The whole process of destruction takes place so quickly that the stems very often become yellow and die within a few weeks.

In the beginning of the foot disease the leaves show a rolling, which is easily confused with that caused by other diseases, but the disease can be readily identified beyond question by the presence of the softened part of the stem, which does not occur in other troubles.

Several bacteria have been found to cause the disease—*Bacterium phytophthorum*, *Bact. atrosepticum*, *Bact. solanisaprum*, and *Bact. xanthochlorum*. It is remarkable that in artificial cultures each of these four species forms long threads in addition to the typical rod-like forms. Perhaps other bacteria may be found to cause black-leg. There are bacterial diseases which soften the stem without blackening it.

During prolonged spells of damp weather the tubers also are attacked in the soil. The bacteria enter the potato through the tiny wounds which are always present and produce a wet rot. This changes the inner part of the tuber into a kind of soft pulp. In such cases, however, the starch is not dissolved, and the cells lie separated.

In Germany, where it is often necessary to harvest potatoes in damp weather the bacteria not infrequently spread through the storerooms and

cellars and destroy a great many tubers. In America the danger from this source is small because of the dry autumns. Indeed it seems to me that black-leg of the potato is of but minor importance in the United States. On my trip I found it only in the far Northeast. I am told that in the Southern and Central States the infected tubers produce diseased plants, but that the disease does not live over winter in the soil, the apparent reason being that the bacteria do not form spores and are very susceptible to dry conditions. In my own experience I have found that a slight drying out is sufficient to kill small infections. The potato closes its wounds with cork and this enables the tuber to overcome these small infections. The same reason is responsible for the excellent results we have obtained in the drying off of potatoes. The tubers are spread out for some days before they are planted and in this way serious damage is prevented.

Finally I wish to call attention to another disease, which I saw in America for the first time and which has not yet been described. In the case of this disease also the leaves are often rolled, black spots occur on different places on the stem, and a mycelium is found in the interior. While in the well-known vascular mycoses the mycelium grows in the cavities of the pitted vessels and but few threads are found, in this unknown disease the primary vessels (the ring and the spiral vessels) are filled with hyphae. Professor Stakman, of St. Paul, who is working on the disease, told me that the mycelium belongs to a *Fusarium* species. Some scientists think the disease a kind of black-leg which has assumed another form because of the plants growing under other conditions. In that case the mycelium would be of a secondary character. I can not share this opinion. I believe the disease is a particular form of vascular mycosis and that when bacteria occur in the vessels they are of a secondary nature. The problem, however, can be solved only by thorough investigation.

The following diagrammatic grouping briefly summarizes the diseases discussed:

I. *Crisp leaves*:

1. Curly dwarf disease.

II. *Rolled leaves*:

1. Non-parasitic—

- A. Leaf-roll disease.

2. Parasitic—

- A. Vascular diseases:

- a. Fungi—Wilt disease.
 - b. Bacteria—Ring disease.

- B. Foot diseases:

- a. Fungi—*Rhizoctonia* disease.
 - b. Bacteria—Black-leg.

A diseased potato plant can not be cured, therefore our efforts should be directed toward prevention rather than cure. Diseases which are carried by the seed potatoes can be prevented. The vascular mycoses and bacterioses are found in the seed tubers when cutting them, the vessels being brown in case of the former and softened in the latter. The problem is somewhat more difficult in the case of black-leg. When the tubers show large areas of infection the disease may be recognized easily but small areas may escape attention. There is no way of determining, however, whether a potato is the product of a plant which was affected with curly dwarf or leaf roll. The farmer should know the disease in the field and mark the diseased vines so that the tubers may not be used for seed. Though not first class the quality of potatoes produced by such plants is relatively good for food so that it is not necessary to destroy the plants.

In Germany we have arrangements for field inspections so that the farmer may be sure of getting rid of these diseases. Whenever a farmer wants an inspection made he applies to the Deutsche Landwirtschaftsgesellschaft (German Agricultural Society) in Berlin, or to a Landwirtschaftskammer (Board of Agriculture), one of which is in nearly every state or province of the Empire. The application must show the variety of potato, source of seed tubers, and the area to be inspected. When the potatoes are in bloom a Commission, consisting of an agriculturist and a pathologist, inspects the field. If 5 per cent of the plants are found to be diseased, the certificate is withheld and if a smaller per cent is found the grower is required to remove the affected plants. Later a second inspection is made and if diseased plants are found the certificate is refused. At this inspection samples are taken from several different parts of the field in order to determine whether the yield is uniform. An ideal seed potato should not only be healthy, but should come from a healthy and prolific mother plant. This is necessary to insure healthy progeny. The farmer is glad to bear the expense of the inspection, knowing he can sell his certified seed at a good price.

This system of inspection is going to be introduced in parts of the United States, that is, in the states having the most progressive potato culture, such as Maine, Wisconsin, etc., and I am sure it will be successful.

Finally, it may be said that the basis for all measures of control is a thorough knowledge of the diseases, and our endeavor should be to spread this knowledge as much as possible.

BERLIN-DAHLEM *

GERMANY

THE LOOSE KERNEL SMUT OF SORGHUM¹

ALDEN A. POTTER

WITH PLATE X AND TWO FIGURES IN THE TEXT

In a paper on the smuts of sorghum in America, the writer (1912)² recently noted the occurrence of *Sphacelotheca cruenta* (Kühn) Potter in this country. It has become evident on further investigation that it has been largely confused with the "closed" or "covered" species, *Sphacelotheca sorghi* (Lk.) Clint. The present paper is intended to clear up this confusion by adequate illustration and discussion of the taxonomy of the species, *Sphacelotheca cruenta*.

This smut was first described by Kühn (1872). Link's (1825: 86) rather obscure original description of the other species under the name *Sporisorium sorghi*, might perhaps seem more fitly to apply to this one because he notes ruptures in the substance of the seed and excrescences in the outer ends of the panicle branches. Kühn (1875) himself, however, examined Ehrenberg's specimens, from which Link described his species, and since he considered that the fungus should be transferred to the genus *Ustilago* in which Passerini had by this time placed a doubtful species named *U. sorghi*, he re-named it *Ustilago tulasnei*.³ It is thus evident that he considered Link's species distinct from his own species, *Ustilago cruenta*, which he had previously described in 1872.

Kühn's descriptions of the latter⁴ appear to be scarcely complete, however, and have apparently led to considerable confusion of the two kernel smuts in literature. The marked emphasis which he laid both upon the formation of sori in the stem (more particularly in the panicle branches) and upon the red coloration from which he drew the specific name, *cruenta*, seems to have been unfortunate, and later writers do not bear him out in this. Thus Brefeld (1883: 91) from material sent him by Kühn, gives the following description:

¹ The writer is greatly indebted to Dr. G. P. Clinton of the Connecticut Agricultural Experiment Station for advice and assistance through correspondence.

² Bibliographic citations in parentheses refer to "Literature cited," p. 154.

³ This species, i.e., the covered kernel smut, having been transferred to the genus *Sphacelotheca* by Clinton (1904: 385), Kühn's objections to the specific name, *sorgi*, no longer obtain under the present rules of nomenclature.

⁴ Besides the original description, cited above, see also Kühn, 1877: 81.

"Das *schwarze*⁵ Sporenlager des Brandpilzes hatte einen eigenthümlichen Stich ins Röttliche, die einzelnen kleinen rundlichen Sporen (von 6-12 μ Grösse) waren eher gelb als braun gefärbt,"

and again, (1895: 43):

"Es ist bekannt, dass der Hirsebrand, *Ustilago cruenta* Kühn, Hirseformen bewohnt und dass die befallenen Fruchtknoten in eine *schwarze*⁵ Brandmasse umgewandelt werden ohnlich wie es bei dem Flugbrande des Hafers geschieht."

He further observes here, moreover, that the sori in a large number of infected plants of *Sorghum saccharatum* were confined to the inflorescence, and mostly to the ovaries, unlike Kühn's descriptions of the type.

Brefeld is not consistent in his classification. He at first (1895: 120) considered *U. tulasnei* and *U. sorghi* the same species. Later (1905: 57) he apparently held the same opinion regarding *U. sorghi* and *U. cruenta*, while his most recent publication (1912: 31) classes all three as distinct species, *U. tulasnei* being distinguished from the others by more sparse conidial formation and a tendency toward hyphal structure in the growth on artificial media. *U. cruenta* is separated only because of the formation of sori on the stem. Although the growth of the two American species has been found by the writer to differ at times on nutritive media, this seems so largely dependent on the character of the medium and other conditions of growth that the lack of a record of these conditions in Brefeld's work makes his classification on the basis of cultural studies seem of doubtful value. Clinton (1897: 375) has called in question the species dealt with by Brefeld in his "chief investigations," largely because of the close similarity between the spores and germination of the two species. These doubts seem dispelled, however, by the more thorough understanding of their real differences, now at hand.

While Brefeld's illustrations (1895: Pl. I, figs. 12 and 13), in connection with his statement that sori seldom appear on the branches (1895: 43) are fairly convincing as to the identity of the American species, it remained for Busse (1904: 373) to note the fragile character of the membrane on the sorus—its most distinctive, constant characteristic. He also calls attention to the fact that Kühn's material was probably not typical and states that, in his material, plants infected by this fungus did not commonly show the red coloration nor crumpling of panicle branches described by Kühn.

From these descriptions we are able to identify the American species here under discussion with Kühn's *Ustilago cruenta*. But for a certain variability which this species has shown in its development on different sorghum varieties in plantings made by the writer (these are described

⁵ The italics are our own.

below), it might readily be suspected, with Clinton (1897: 375), that the later authors, Brefeld and Busse, were not dealing with the same species that Kühn had. Busse (1904: 371) has called attention to the possibility of this variation, dependent upon host varieties, in describing the other species of kernel smut, *Sphacelotheca (Ustilago) sorghi*.

Using spores from a single lot the writer made inoculations at Amarillo, Texas, in 1911, on six different varieties of sorghum. Milo proved immune, as it has from the other smut forms. A saccharine sorghum, the Red Amber variety, yielded 10.9 per cent of infected plants, and like Brefeld's descriptions, the sori were for the most part confined to the ovaries. This was true also of kafir (Pl. X, fig. 1), of which 13.8 per cent was smutted, and broomcorn with 6.9 per cent infection.

On the other hand a Brown kaoliang, showing 10.3 per cent smutted plants, and Freed sorgo, a sub-saccharine form somewhat similar to the kaoliangs (with 5 per cent infection), frequently showed the typical lesions described by Kühn. Two panicles affected in this way are shown in Plate X, figures 3 and 4. These lesions, like all injuries on sorghum—particularly in the case of saccharine varieties, developed more or less of a reddish color. This, however, is plainly a characteristic, not of the parasite, but of the host. Even in the saccharine varieties the coloration is at least not conspicuous in sori which happen to be confined to the flowering parts.

In Plate X, figure 2, is shown a young smutted inflorescence of Freed sorgo preserved with many unbroken sori, much as in one of Brefeld's illustrations (1895: Pl. I, fig. 12). This is unusual, particularly in the Great Plains areas where the high winds break the thin membrane as soon as it emerges from the sheath. The most typical form is shown in figure 1 of the plate. The long, naked columellae may be seen projecting from the glumes, the whole head appearing, as Brefeld aptly expresses it, much like a chimney-sweep's broom.

Parallel inoculations with *S. sorghi* made at the same time, and on the same varieties as those with *S. cruenta* showed the two forms to be entirely distinct macroscopically. This will appear from a previous illustration by the writer (1914: Pl. XXXII, fig. 1).

To these macroscopic distinctions should be added a few statements as to microscopic characters. The spores of the two kernel smuts are difficult to distinguish. Those of *S. cruenta* are somewhat more irregular in size and shape and thus average a very little larger. In measurements made by the writer their average diameter has usually been slightly more than 6 μ , while the other species has averaged slightly less, although this is not always true. Dr. G. P. Clinton has found, however, in examining our own and other exsiccati, that the fragility of the membrane in the

loose kernel smut is apparently due not only to its thinness (fig. 1) but also to the fact that the "cells are more nearly spherical and separate easily into small groups or individual cells which are usually much larger than the spores: while the membrane of *S. sorghi* is more permanent, less easily broken up, and consists chiefly of cells that are more elongated, with shorter diameter, usually not larger than that of the spores, and when pressed apart are apt to adhere in thread-like groups."⁶ These large, spherical, hyaline cells (fig. 2 a) can be found characteristically scattered

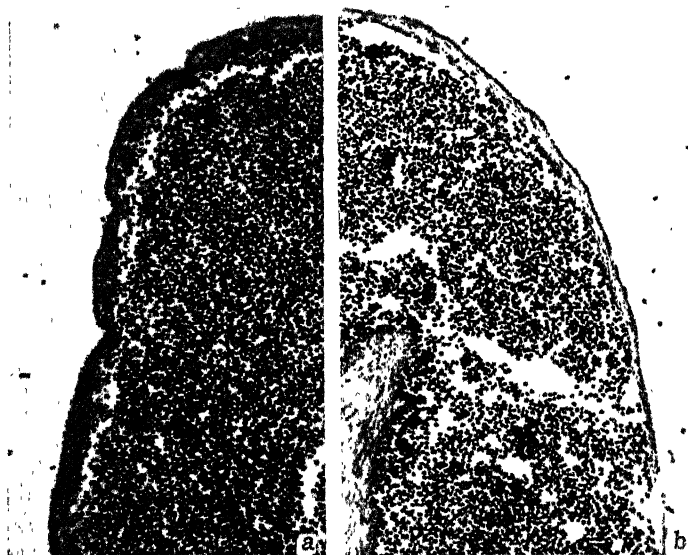


FIG. 1. a, sector of a longitudinal section through apical portion of a young sorus of *Sphacelotheca sorghi* on kafir, grown at Amarillo, Texas, in 1912. Enlarged 100 diameters; b, preparation similar to that of a, but of *S. cruenta*. A portion of the columella appears in the figure. Note also the membrane, which is typically much thinner than in the other species. Photomicrographs made by the author, 1914.

through the escaped spore mass in herbarium material. They usually measure up to 12 μ or more in diameter, although some may be no larger than the spores.

American literature has not recognized this species although it has apparently been present for many years. Specimens collected by officials of the Office of Cereal Investigations of the United States Department of Agriculture show it to have been in this country previous to 1906. It also appears that the oldest specimen of sorghum smut in American exsiccati, Ellis' North American Fungi, No. 1496, collected by Trelease in

⁶ Letter of March 30, 1914.

Wisconsin, is not of *Sphaecelotheca sorghi*, as reported, but of *S. cruenta*. Trellease (1885: 138) apparently noted its lack of the typical appearance but did not consider it distinct. His observation that it was imported with Chinese seed agrees with its appearance among the kaoliangs in the plantings of the Office of Cereal Investigations. Dr. G. P. Clinton has also kindly submitted a specimen collected by Thaxter from Kingston, Jamaica in 1891. The only other specimen in American herbaria, so far as is known to the writer, is one in the Farlow herbarium collected by Kühn, himself.

That the species has also been confused in European herbaria would appear from an examination of such specimens as Jaczewski's *Fungi Ros-*

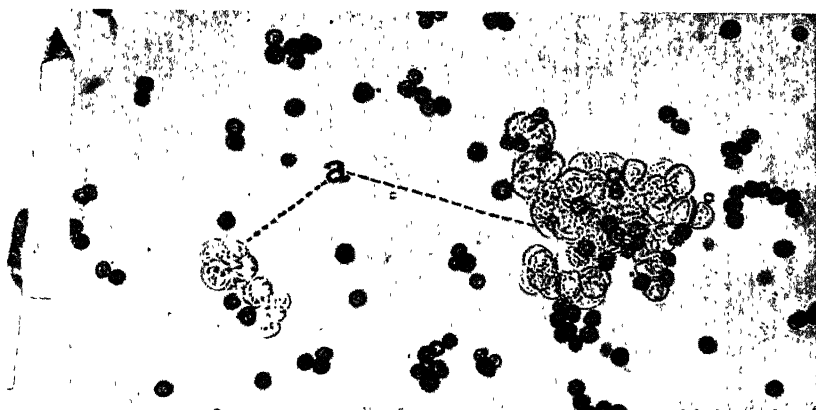


FIG. 2. Typical spore material of *Sphaecelotheca cruenta*. $\times 350$. Note the large, sterile cells in two groups at *a*. Photomicrograph made by the author, 1914.

siae Exsiccati, No. 206, collected in Manchuria in 1896, and Vestergren's *Micromycetes Rariores Selecti*, No. 1209.

A brief study of the amenability of this smut to control by seed treatment was made in 1912. The formalin treatment (Freeman and Umberger 1910: 6) was found to eliminate infections of 12.5 and 15.7 per cent in kafir and broomcorn, respectively. It should be said that in these tests, and in others with *S. sorghi* on different varieties, it has been found that seed which has retained the glumes through the thrashing process, as does broomcorn, will usually sustain, without injury, a more severe treatment than naked seed, and at the same time requires a more severe treatment in order to be certain of prevention. This protective action of the glumes appears again in the fact that usually more severe infection is sustained in the field by plants grown from smut-infested seed which has no adhering glumes.

SUMMARY

The confusion of two, distinct, American species of kernel smut on sorghum has resulted largely from the undue emphasis laid by Kühn on certain peculiarities of the species, *Ustilago cruenta*, which he described in 1872.

The occurrence of this species in America as early as 1885 is established. It is shown that its most distinctive character is the fragility of the membrane enclosing the sorus. This is dependent not only upon its thinness, but also upon the more nearly spherical shape of its cells.

Infection may be prevented by the usual seed-disinfecting treatments.

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OFFICE OF CEREAL INVESTIGATIONS

BUREAU OF PLANT INDUSTRY

U. S. DEPARTMENT OF AGRICULTURE



POTTER: LOOSE KERNEL SMUT OF SORGHUM

EXPLANATION OF PLATE X

Sphacelotheca cruenta on 1, kafir, 2, Freed sorgho, 3, Brown kaoliang, and 4, Freed sorgho. Enlarged. Note that in 3 and 4 the stem and branches of the panicle are involved. In 2 the sori are comparatively intact because the specimen was taken when young, while in 1 they are all broken and most of the spores dissipated. Photographed by Mr. J. F. Brewer, 1914.

SOME NEGLECTED PHASES OF PHYTOPATHOLOGY

J. G. GROSSENBACHER

INTRODUCTION

The influence of the environment on the development and maturation of tissues is evidently far-reaching, but scarcely a beginning has yet been made in determining it. The effects of sub-optimal conditions on growing plants are largely unknown except in their extremes and only very imperfectly even there. Phytopathology has been too much concerned with the morphology and physiology of the microorganisms associated more or less constantly with many diseases of cultivated plants, to permit continuous and thoroughgoing studies of the seasonal and life history of the tissues first affected by the early stages of disease. This has tended to discourage investigations into the conditions that precede such visible derangements in plants. In fact, this one-sided development of phytopathology has been so marked in the United States during the past fifteen years that the special departments devoted to this work are still concentrating most of their teaching energies on the study of fungi and bacteria along with methods of preventing the diseases with which some of these organisms are connected. The early development of human pathology was not thus sidetracked because in those days the relation of certain microorganisms to disease had not yet been discovered. By the time Pasteur appeared upon the scene medical schools had developed so far along histological and physiological lines that the germ theory of disease only added to and modified their courses but did not eliminate or wholly supplant further research along the old lines. Phytopathology has not this foundation. General physiology and histology along with Küster's *Pathologische Pflanzenanatomie* would furnish most of the general principles on which such a foundation could be built. At the present time these more basic considerations are merely tolerated and not amalgamated with what passes for plant pathology. The prime importance of the physiology and histology of the host as affected by the environment is usually not even recognized. A man proficient in the knowledge available on the pathogenic microorganisms related to the diseases of human beings would not be granted permission to practise medicine, while one so prepared in regard to some of the organisms associated with most of the best known diseases of plants is given high rank in plant pathology.

However, plant pathology has attained some results of most extraordinary economic importance in the United States in recent years, especially on the prevention of certain diseases of herbaceous plants, and on some of those affecting the leaves and fruits of woody plants. On the other hand, very little actual progress has been made in our knowledge pertaining to the diseases affecting the bark of woody plants and those of the phloem of herbs; that is, of the diseases which originate in the interior, or to those which are related to the development and life history of the more permanent tissues. Practically the same is true as regards a real understanding of the primary causes of fruit-rots. We know, for instance, that careful handling and provision for good aeration in getting fruits to market usually reduces the amount of rot decidedly, also that in case of certain fruits spraying with fungicides is of great value; yet during years of certain peculiar weather combinations when fruits drop easily or decay even on trees low temperature must be used to prevent rot in marketing. In such seasons our ignorance of the real combination of factors leading to decay is brought forcibly to our attention and most of us are willing to shift the scene.

European phytopathologists have been following the lead of those in the United States in the more practical phases of the work. The growers in Europe are not in as close touch with their investigators, and have not compelled as much attention. The development of the spraying business has therefore lagged behind that in this country. Nevertheless their advances have been notable and perhaps more fundamental than ours. They have been investigating many of their problems more from a standpoint of the host and its environment. Some recent contributions from there show that such considerations are assuming more and more prominence in their research.

SORAUER'S WORK

This trend in Europe is also brought out by comparing the first, second and third editions of Sorauer's *Handbuch der Pflanzenkrankheiten*. That veteran pioneer in plant pathology has developed some most promising points of view and methods of attack, many of which are so far ahead of his time that they are attracting but minor attention and therefore enlist few followers. He has dared attack the more abstruse problems. His extensive studies on plant diseases during the many years that he has given to the subject show a gradual change of view in regard to the primary causes of diseases of certain types. This is especially indicated by comparing the space devoted to diseases of parasitic and those of non-parasitic origin in the three editions of his *Handbuch*. In the first edition 147 pages are given to those of non-parasitic and 190 pages to those of

parasitic origin. In the second edition non-parasitic diseases are discussed on 715 pages and those due to plant parasites on 430 pages, while to insect and other enemies 116 pages are given. In the third edition non-parasitic diseases occupy 877 pages, those due mainly or in part to plant parasites 535 pages, and troubles chiefly due to insects and other animals take up 747 pages.

Although one may not always agree with the interpretation of the facts about diseases described in the first volume of the last edition, the mass of material collected and classified in its pages is invaluable as a source of reference as well as of inspiration. His discussions of the environmental factors as related to the development of specific diseases, and the histological details given about many of them are illuminating and suggestive in most cases.

LEAF-ROLL DISEASE OF POTATO

A problem that affords a fair illustration of the more obdurate diseases to understand is leaf-roll of potato. The various attempts that have been made in the past to fathom the cause either failed or at least were only partial successes. The present status of the problem, however, is much better than that of many others which have long since been dismissed from further investigation as solved. In this case one can readily imagine he discerns something not far removed from the first marked effect of the cause, even though it is seen only with a telescope instead of with a microscope; for that reason one can as yet give only certain characteristics of it.

In a recent paper on this disease of potato Quanjer¹ not only discloses some very important facts regarding this particular malady but makes use of a method of approach that should be more general in the study of diseased plants. He found that the disease in question is not due to pathogenic organisms but that it is connected with a necrosis of the phloem strands. As is well known, affected plants ordinarily remain small, have short stolons, their leaves are more or less rolled up and the yield of tubers is much reduced. In the plants affected by leaf-roll both the extra- and intraxylar strands of phloem were always found discolored and collapsed more or less. In milder cases only the oldest phloem strands or those nearest the bast-fiber groups inside as well as outside of the xylem, were involved. A disorganization of the phloem is said to take place which is apparently accompanied or preceded by a slight lignification of

¹ Quanjer, H. M. Die Nekrose des Phloems der Kartoffelpflanze, die Ursache der Blattrollkrankheit. Meded. Rijks Hoogre Land, Tuin en Boschowsch. (Wageningen) 6: 41-80. 1913.

the cell walls. Measurements made on the phloem cells of normal and affected strands of three varieties of potatoes showed the diseased cells to be on an average from 26 to 36 per cent shorter than the normal ones. It is thought that the shrinkage and lignification of the affected phloem exert a pull or tension on the surrounding tissues, owing to the fact that the parenchyma cells adjoining the affected phloem are found elongated or drawn-out toward the collapsed phloem.

The first traces of the discoloration of the phloem strands were sometimes found present in young stems after a few leaves had become unfolded, and the discoloration is said to follow elongation growth upward and at such a rate that the phloem of the new internodes shows indications of it before that portion of the stem has attained full size; in other cases the discoloration did not become evident until the plants were large, or after the "seed" tuber had disintegrated. In 1912 some of the early stages of the disease were found in the distal internodes of plants as late as August and September. The degree or extent of injury was found to decrease toward the distal ends of the plants as well as toward the "seed" tuber underground, although the affected strands may be traced to both leaves and "seed" tubers. In the lower aerial internodes where considerable secondary growth occurs, the injury is also chiefly confined to the oldest extraxylem and to the intraxylem strands of phloem.

The black discoloration of the dead spots in the leaves of such affected plants is thought to be due to an injurious accumulation of proteins as well as that of mineral substances in them owing to the stoppage in the downward flow of proteins through the phloem. It is noted that the varieties of potato which are ordinarily resistant to *Phytophthora* blight are severely blighted when affected by phloem necrosis. Plants dying from phloem necrosis do not become defoliated when they die but the leaves, surcharged with elaborated food, die and turn black and remain attached to the stems. Quanjer thinks that lignification and other processes are instituted during the dying of the phloem cells, though this was not definitely established. The chief difference between the normal change of the older phloem to its functionless and collapsed state as it occurs in the bark of trees, et cetera, and that occurring in the necrotic collapse of the phloem in such diseased potato plants is thought to consist in the biotic changes, which are absent from normally dying phloem.

The lignification of the phloem has been noted in a number of apparently normal plants although the question has been studied but little. Vesque² found that in *Betula alba* lignification of the phloem may occur

² Vesque, J. Memoire sur l'anatomie comparée de l'écorce. Ann. Sc. Nat. Bot. Ser. 6, 2: 82-198. 1875. (178-79).

comparatively early in the life history of the tissues. Schumann³ also noted the occurrence of lignified phloem cells in *Scorzonera hispanica* and *Aster thyrsoiflorus*. The sieve plates were often found especially strongly lignified in these plants. Boodle⁴ has more recently studied some plants showing more or less lignification of the phloem. In the thicker portions of sunflower stems he found that in August patches of phloem-ray cells and the walls of some sieve tubes were lignified, while in October lignification of both the sieve tubes and companion cells had occurred and the cell contents showed the lignin reaction. Sometimes only scattered groups of cells in the phloem bundle possessed lignified walls. Boodle thought that cultural or environmental conditions and the relative robustness of plants determine the degree of lignification that will occur in the phloem.

Quanjer thinks that phloem necrosis of the potato is due to a slight functional derangement in the phloem which interferes with the normal transportation of elaborated foods and results in its accumulation and thereby giving rise to some poison which induces the disease. Susceptibility to this malady is thought to be inherited. He notes that in cases where discoloration or phloem injury is slight, lignification is correspondingly slight, and for that reason assumes that the dying process induces lignification.

It is a well-known fact that frequently after the protoxylem cells and strands of the stems of various plants are practically mature and more or less lignified they are stretched and even ruptured by the further elongation of the axis. In many plants such stretched and ruptured protoxylem cells occur in nearly all parts of the axis, but the phenomenon is especially common in the basal portion of stems and branches where the elongation and maturation processes more often interlock. Since the measurements of diseased phloem cells made by Quanjer show that they are from 26 to 36 per cent shorter than the normal ones of the same stem, and since such affected cells are in the older portions of the phloem it appears at least possible and perhaps probable that the causes of injury are very similar to those inducing the injury and rupture of protoxylem cells. The normally short-lived nature of protoxylem and its small content of protoplasm in connection with the fact that its function is so quickly supplanted by that of the regular xylem are doubtless the chief reasons why no serious disturbances follow such protoxylem injuries. The disintegra-

³ Schumann. Beitrag zur Anatomie des Compositenstengels. Bot. Centbl. 41: 193-96. 1890.

⁴ Boodle, L. A. On lignification in the phloem of *Helianthus annuus*. Ann. Bot. 16: 180-83. 1902.

tion of the protoplasm of injured phloem cells not only interferes with the normal transfer of elaborated foods but seems to give rise to some diffusible substance that may injure and kill adjoining cells. However, this does not explain how it is that in a growing stem lignification may overtake elongation growth and thus result in injuries, yet it suggests that such things might happen if the environment were unfavorable to elongation growth during the early developmental period of an axis.

I consider this work of Quanjer of much importance because it is a type of research in phytopathology that is needed in a number of our most dreaded plant diseases, including some of both woody and herbaceous plants. For example, the bark diseases of trees and shrubs and some of the other stem diseases of herbaceous plants could doubtless be studied with profit from the standpoint of the relation between the life history of the affected tissues to the development of such diseases as was done by Quanjer.

BARK DISEASES OF FRUIT TREES

During the past five years I have been studying certain bark diseases of fruit trees. Most of the first three was devoted to a trouble of apple trees that results in the death and decay of the bark on the trunk at the ground, and is known as crown-rot.⁵ Since then much time has been given to study of a very similar disease of Citrus that is usually known as foot-rot. The similarity of these two troubles consists chiefly in the fact that they begin with the disintegration of the inner phloem or cambium.

Crown-rot was concluded to be of nonparasitic origin. It was found most prevalent following winters in which the first cold period came while the bark at the base of some tree trunks was still growing. Similar injuries developed at crotches and other places where elaborated food is most abundant in fall. A fairly complete series of the various stages in the development of so-called cankers and crown-rot were secured by fixing specimens collected from late winter to mid summer, in killing fluid.

The simple statement that there is a connection between the initial stages of this trouble and the occurrence of low temperature affords no explanation of the cause. For that reason most of the available literature on tree growth and its relation to the factors of the environment, was collected and reviewed with the hope of gaining some information and points of view that might prove of use in the study of crown-rot. The result was gratifying in that a great and varied fund of ideas was

⁵ N. Y. State Agr. Exp. Sta. Tech. Bulls. 12 (1910) and 23 (1912).

secured,⁶ but proved rather disappointing in that only occasional suggestions having direct bearing on the problem in hand, were found. My observations which showed that late radial growth may be very irregularly distributed were found to have been made also by some other investigators. This review of the literature together with my own studies suggest a few fairly plausible ideas on some of the causes of crown-rot. These notions are not established facts, however, and whatever value they may have lies mainly in pointing the need for further work. Most of my attention was necessarily given to the development of the disease from the initial injuries by making a histological study of the material collected preceding and during growing seasons.⁷

A similar plan of attack has been followed while studying foot-rot and gummosis of Citrus during the past two and a half years. The strange and perhaps unexpected likeness of the irregular distribution of late-season radial growth was also brought to light in regard to Citrus. It was found, too, that cold snaps induce injuries in some such actively growing regions of bark. It appears probable, however, that at least in Florida some other adverse factors of the environment, may also induce phloem and cambium injuries that subsequently result in bark diseases. The material for a histological study of the development of these Citrus troubles does not make a complete series as yet, but enough is at hand to permit the publication of a preliminary report on the subject once the final paper on the crown-rot of apples has been finished.

This rambling discussion of what are deemed types of phloem and bark diseases of herbs and woody plants does not aim to present details but only to call attention to some of the problems in phytopathology that deserve more general attention not only because they are of fundamental scientific interest but also because they are equally important from an economic standpoint. Such diseases not only damage or destroy one crop but actually kill trees which it has taken many years to produce.

The study of problems of this kind does not yield the self-satisfying and quick results sought by most investigators. To spend a few months in trying to determine the cause of such a malady as leaf-roll, fruit-rots, or any of the various bark diseases of trees like peach yellows, for instance, and then spend a half dozen years in studying the morphology, physiology and life history of any microorganisms that may be found trespassing on such affected plants yields only minor advances and diverts attention

⁶ The periodicity and distribution of radial growth in trees and their relation to the development of annual rings. *Trans. Wisc. Acad. Sc. Arts and Letters* 18: — 1915.

⁷ A paper is now in preparation on this phase of the subject.

from the fundamental problem to be solved. It is more conducive to progress to become acquainted with only a portion of a main line than to run to the end of a short branch, because other investigators may explore different sections of the field and thus enable someone to bridge the remaining gaps and give us a complete solution of the causes. Once the causes of a disease are fully known preventives or correctives can usually be found with much less labor.

U. S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

EXPERIMENTS ON THE SUSCEPTIBILITY OF SWEET POTATO VARIETIES TO STEM ROT

L. L. HARTER AND ETHEL C. FIELD (TILLOTSON)

The large losses sustained by sweet potato growers from the stem rot in New Jersey led the writers to make a study of this disease in the hope of discovering some remedial measures. The results of this investigation, which extended over two years, were published in *PHYTOPATHOLOGY*¹ (1914), where the symptoms of the disease, the causal organisms (*Fusarium hyperoxysporum* Wr. and *F. batatatis* Wr.), extensive inoculation experiments and various other features were discussed. In all the experiments the Yellow Jersey variety, which is grown extensively in New Jersey, Delaware, part of Maryland and a part of Virginia, was used. A study of a disease of a single variety, however, in a limited region can not be taken as typical of the crop in general, especially in a country where so many different varieties of sweet potatoes are grown under such diversified climatic conditions. It was well known that stem rot did not occur in some localities, but it was not certain whether this was due to the fact that the disease had not been introduced or whether resistant varieties were being grown. Investigation indicates that both suppositions are true. In fact, regions are known where, at the present time, a very susceptible variety is growing entirely free of stem rot, viz: Nancy Hall at Newton, North Carolina and at Orangeburg, South Carolina. Furthermore, certain varieties are known to be grown entirely free from stem rot in localities where a large percentage of susceptible varieties are affected by the disease, viz: Yellow Yam at Lincoln, Arkansas and Triumph at Foley, Alabama.

Since the disease is a vascular trouble and is propagated largely through infection of the plants in the field, there seems to be but two methods through which control may be sought; first, that of obtaining a variety or varieties resistant to stem rot, or, secondly, of obtaining a strain in a variety which is resistant. The present paper gives the results of variety tests which were carried on during the two seasons of 1913 and 1914.

Experiments were conducted at Vineland, New Jersey, on the Potomac flats, Washington, D. C., and at the Arlington Experiment Farm. In

¹ The stem rot of the sweet potato, *Ipomoea batatas*. *Phytopathology* 4: 279-304, plates 24-26. 1914.

1913 at Vineland, seven varieties obtained from the Office of Horticultural and Pomological Investigations were planted in infected soil. These same varieties and others were planted on the Potomac flats in 1913 and at the Arlington Experiment Farm in 1914 and inoculated with *Fusarium hyperoxysporum*. All inoculations were made by inserting spores and hyphae into wounds made at the base of the stems, care being taken not to injure the plants any more than necessary. *Fusarium hyperoxysporum* was used for all inoculations because it is the more vigorous parasite of the two species causing stem rot and, likewise, the more widely distributed.² The cultures used were in the stage known as high culture, that is, a culture containing a maximum of septate, sickle-shaped spores and a minimum of hyphae. No attempt has been made to test out all varieties of sweet potatoes. There are more than 200 commercial names for this crop, but probably less than 30 true varieties. Most of those of commercial importance have been included in these tests.

The results of the experiments are recorded in the following tables:

DISCUSSION OF RESULTS

The first records of the results of inoculations were made merely from a superficial examination of the plants. It is not always possible to tell definitely whether a plant is infected without opening the epidermis. This was not done, however, until later in the summer, since very young plants might be killed by such mutilation rather than by the fungus. Later in the season when the plants were strong, the epidermis was frequently opened whenever there was any doubt.

It is seen from table 1 that 15 different varieties were inoculated in 1913. Successful infections were produced on plants of eight of these varieties. All plants were recorded as infected when the bundles were blackened for a few inches in each direction from the point of inoculation. It must be remembered that by the use of such a method many plants were recorded as infected which were not materially injured. In most cases those varieties which showed the largest percentage of infection were the ones most severely injured by the fungus, as, for example, in table 1, Early Carolina, Nancy Hall, Red Jersey and Yellow Jersey. It should be noted also that the fungus invaded the roots of some of the plants of these varieties. The organism was recovered from the vines and roots of many infected plants.

In 1914, inoculations were made on 12 of the varieties used in 1913 (table 3). The Yellow Jersey, Early Carolina and Red Bermuda were

² Stem rot has been found to occur in the states of New Jersey, Delaware, Maryland, Virginia, Ohio, Illinois, Missouri, Iowa, Kansas, Oklahoma, Arkansas, North Carolina, Georgia, Alabama and Mississippi.

omitted. Plants of the Red Bermuda could not be obtained and the susceptibility of Yellow Jersey and Early Carolina to stem rot was so well known that further experiments were thought unnecessary. Four varieties, the Yellow Yam, Miles Yam, Vineless Yam and General Grant Vineless Yam, were used in 1914 but not in 1913. It will be seen from table 3 that some plants in all varieties were infected, the number in several cases, however, being quite small. As in the previous year some of the plants recorded as infected were not very greatly injured. Roots from one plant each of five varieties, viz., Georgia, Vineless Yam, Yellow Yam, Key West Yam and Nancy Hall, became diseased.

From table 2 it is seen that some plants of all varieties except Southern Queen were infected when planted on infected soil, the percentage in some cases being high. The roots of a number of plants were likewise diseased.

These experiments show that the varieties Early Carolina, Yellow Jersey, Red Jersey and Nancy Hall are particularly susceptible to stem rot under natural conditions in New Jersey and when artificially infected at Washington, D. C.

These same varieties are equally susceptible to the disease when grown normally under field conditions in other sections of the country. The Big Stem Jersey and Yellow Jersey varieties are grown extensively in Illinois, Iowa and Kansas and in these sections suffer as much from stem rot as they do in New Jersey. Nancy Hall, a variety not grown in New Jersey or Delaware on a commercial scale, appears to yield to the stem rot as readily there as in Iowa, Arkansas, North Carolina or Alabama and at Washington, D. C., when artificially infected. On the other hand such varieties as Dahoney, Red Brazilian and Yellow Strassburg which show a high degree of resistance when grown normally under field conditions were likewise the more resistant when artificially inoculated. In general these results seem to indicate that inoculation experiments furnish a fair standard for judging the relative susceptibility of sweet potato varieties to stem rot. Two other varieties,³ Porto Rico and Providence, on which no inoculations were made, are quite susceptible to stem rot under field conditions in Alabama.

However, the substitution of one variety of sweet potatoes for another in any region cannot be done alone upon the basis of their resistance to disease. In the first place, it is a well-known fact that a variety which is prolific in one region is not necessarily so in another. For instance, the Yellow Jersey, which produces a potato of exceptional quality and shape in New Jersey and Delaware, produces a very stringy, rooty potato in the South. Furthermore, some of the very productive sweet potatoes

³ Harter, L. L. Notes on the distribution and prevalence of three important sweet potato diseases. *Phytopathology* 5: 124-126. 1915.

TABLE 1

Results of inoculating different varieties of sweet potatoes on the Potomac Flats, June 15, 1913

VARIETY	NUMBER INOCU- LATED ¹	NUMBER INFECTED JULY 3	NUMBER INFECTED JULY 16	NUMBER INFECTED OCTOBER 14 ²	ROOTS INFECTED	PER CENT OF INFECTION
Nancy Hall.....	34	27	27	28	4	82.3
Early Carolina.....	37	16	19	22	1	59.4
Yellow Jersey.....	35	0	10	16	4	45.7
Red Jersey.....	40	10	16	18	3	45.0
Georgia.....	35	6	8	8	0	22.8
Southern Queen....	68	9	9	9	0	13.2
Eclipse Sugar Yam.....	32	4	4	4	0	12.5
White Yam.....	33	2	2	2	0	6.0
Florida Yam.....	39	0	0	0	0	0.0
Pierson.....	38	0	0	0	0	0.0
Yellow Strassburg.....	43	0	0	0	0	0.0
Key West Yam.....	32	0	0	0	0	0.0
Red Bermuda.....	40	0	0	0	0	0.0
Red Brazilian.....	40	0	0	0	0	0.0
Dahoney.....	40	0	0	0	0	0.0

¹ Ten checks were used for each variety. These plants were punctured at the base of the stem in the same way as those inoculated. None became infected.

² Potatoes were dug and final records made on October 14.

TABLE 2

Results of planting different varieties of sweet potatoes on infected soil during season of 1913 at Vineland, New Jersey

VARIETY	NUMBER PLANTED	NUMBER INFECTED JULY 15	NUMBER INFECTED AUGUST 12	NUMBER INFECTED OCTOBER 15 ¹	ROOTS INFECTED	PER CENT OF INFECTION
Early Carolina.....	110	0	9	28	8	25.0
Yellow Jersey.....	282	7	17	54	12	19.1
Red Jersey.....	105	1	3	14	5	13.3
Nancy Hall.....	110	0	0	6	0	5.4
Georgia.....	76	0	0	2	0	2.6
Miles Yam.....	109	0	0	1	0	0.9
Southern Queen.....	109	0	0	0	0	0.0

¹ Potatoes were dug October 15 and a record made of the number of diseased plants and roots.

TABLE 3
Results of inoculating different varieties of sweet potatoes on Arlington Farm, June 16, 1914

VARIETY	NUMBER INOCU- LATED ¹	NUMBER INFECTED JULY 1	NUMBER INFECTED JULY 7	NUMBER INFECTED JULY 15	OCT. 14 ² NUMBER PLANTS DEAD OF THOSE MARKED INFECTED JULY 15	NUMBER DISEASED	PLANTS RE- COVERED ³	TOTAL NUMBER NOT IN- FECTED AT ANY TIME DURING SEASON	ROOTS INFECTED	TOTAL PLANTS DISEASED DURING SEASON	PER CENT OF INFECTION
Red Jersey.....	34	22	28	31	28	4	2	0	0	34	100
Nancy Hall.....	33	26	27	31	28	3	0	2	1	31	93.9
Gen. Grant Vineless.....	38	29	29	29	13	18	3	4	0	34	89.4
Key West Yam.....	43	25	26	30	27	8	1	7	1	36	83.7
Eclipse Sugar Yam.....	26	6	7	13	9	11	1	6	0	21	80.7
Yellow Yam.....	42	16	17	22	18	7	1	16	1	26	61.9
Vineless Yam.....	29	9	11	14	9	7	1	12	1	17	58.6
Southern Queen.....	46	16	16	16	10	15	2	19	0	27	58.6
Georgia.....	47	6	12	20	14	11	0	22	1	25	53.1
Florida.....	29	10	10	10	3	10	1	15	0	14	48.2
Yellow Strassburg.....	44	8	8	8	1	17	1	25	0	19	43.1
Miles Yam.....	35	1	1	2	2	12	0	21	0	13	37.1
White Yam.....	38	9	10	10	4	6	1	27	0	11	36.8
Pierson.....	43	5	5	5	0	14	0	29	0	14	32.5
Red Brazilian.....	30	3	4	5	1	7	2	29	0	10	25.6
Dahoney.....	30	3	3	3	0	2	2	35	0	4	10.2

¹ Ten checks were used for each variety. These plants were punctured at the base of stem in the same way as those inoculated. None became infected.

² Plants were dug and final records were made on October 14.

³ This shows the number of plants which either recovered from the disease or where the old vine died and new healthy sprouts formed.

in the South, such as Red Bermuda and Florida, scarcely make potatoes in northern states.

Certain varieties of sweet potatoes have been grown continuously in some regions for many years. This continuous use of one variety has enabled the farmers to establish a good market for their crop. For example, the Yellow Jersey, grown largely in New Jersey and Delaware, finds a ready market in the large cities of the East. These markets do not willingly take the yam types grown extensively in the South. The growers therefore would lose a profitable industry even though the southern types might thrive well, or, at least, would be compelled to build up a new market for their crop. In the South where the yam types are mostly produced a different market has been established, and one which prefers those types to any others. In fact, the markets preferring the southern sweet potatoes do not like the Yellow Jersey or similar varieties and will not take them if others can be secured. Where such local conditions are met with the only apparent solution of the problem appears to be the establishment of a resistant strain by selection.

BUREAU OF PLANT INDUSTRY

UNITED STATES DEPARTMENT OF AGRICULTURE

WASHINGTON, D. C.

OBSERVATIONS RELATIVE TO AN OBSCURE GRAPE AFFECTION

F. E. GLADWIN

WITH ONE FIGURE IN THE TEXT

During the summer of 1910 the attention of the writer was attracted to the sickly appearance of the leaves of several Concord vines growing in a young vineyard 3-years-set, on the experimental grounds of the New York Agricultural Experiment Station at Fredonia. In the year 1911 the trouble again appeared in this vineyard and also in others 6-and-7-years-set respectively. In 1912 the affection was present in all the vineyards mentioned, and in addition, in one 23-years-set and located on a very different soil type from the others.

In 1913 the trouble was again present in all the vineyards except in the 23-years-old one, and in addition in two others that were set in 1910. In 1914 the same condition appeared with the exception of the oldest vineyard as noted for the season of 1913. Of the five years in which this disease has been noted, that of 1912 is the one in which the trouble was the most serious.

At its first appearance the disease was associated with Chlorosis of the old world, but close observations, and examinations of the literature pertaining to this disease tend to show that the two are not due to the same causes. Limestone soils are not common in the Chautauqua Grape Belt, and in fact the soils on which these vineyards are located are deficient in lime. Thus far the addition of lime to these soils has not influenced the affection either by increasing or lessening it.

The leaf blight disease described by Fairchild¹ while having some symptoms and environmental factors in common, differs from the one under discussion in several material points. He states that leaf blight is common only to young vines 3 to 4-years-set. Our observations show, that under certain conditions which will later be described, the present trouble can be found on much older vines.

Again he says that "the worst attacks of the disease occur upon cold, heavy soils containing a large percentage of clay and rich in nitrogenous matters." It is true that four of the vineyards under discussion are situ-

¹ Fairchild, D. G. Diseases of the grape in western New York. Jour. Myc. 6: 95-98. 1891.

ated upon heavy soil types yet they are deficient in nitrogen, as has been shown by chemical analyses and the response to applications of stable manure and commercial nitrogen. One of the vineyards, the one 23-years-set, and in which the disease was observed in severe form, in only one year 1912, is planted on a loose gravelly loam of an approximate depth of 20 feet. Another is on a light clay to silt loam and well drained.



FIG. 1. Grape leaf showing typical marginal and intervenular blighted areas.

In some respects the symptoms manifested by the vines later described, are similar to those of the California vine disease of *Vinifera* varieties, discussed by Pierce,² yet the two are so different in other particulars that they can not be attributed to the same causes. Pierce states that cuttings taken from vines affected with the California vine disease carry with them the disease and thus it is perpetuated. Cuttings taken from

² Pierce, N. B. Grape diseases on the Pacific Coast. U. S. Dept. Agr., Farmers' Bul. 30: 7-14. 1895.

vines with the affection under discussion have not, after three years growth, shown that they carry the sickness, but are perfectly normal in top and root.

During the dormant season there are no external evidences that would indicate the trouble, except that wood growth is not as well matured nor is it so great as on the unaffected vines. However early in July in average seasons the apical leaves of affected shoots show a streaked yellowing in the intervenular spaces. The vineyardist but rarely observes this, the beginning stage. A little later other leaves on the shoots develop a pallidness. The discoloration is more marked near the margin and eventually the pallid areas coalesce, and form a yellowed band extending around the margin. As the season advances this band of tissue dries and becomes functionless. The deadened area is further increased by a drying out of the intervenular tissue, extending from the margin inward to the midrib until in extreme cases the entire tissue of the leaf, except that along the main veins becomes brown and dead. Often only one side of the leaf shows this extreme stage; in other cases, after the margin is dead, isolated and scattered spots of dead tissue develop, without order, over the blade, and these may coalesce so that dead areas of considerable size are produced quite apart from those at the margin. A leaf that has gone through the successive stages of dying back from the browning of the margin, and subsequent killing inward of intervenular tissue, has only narrow strips of green living tissue immediately adjacent to the principal veins and veinlets; all other tissue is brown or black. When the entire leaf is affected it often becomes curled.

During the first year an affected vine may be diseased in but few shoots from a single cane, or at most on two or three canes. The year following additional canes and shoots may show the trouble until the whole vine is affected. It appears to be cumulative. Vines have been observed that were completely defoliated some time previous to the period of maturity. The fruit of affected vines does not color nor is the normal amount of sugar fixed. The berries do not acquire full size and in extreme cases shell from the cluster. When the vine is only moderately affected shelling may not follow but the fruit is not attractive nor palatable.

The wood growth is checked materially, and such as there is, does not mature properly, so that much of it is winter killed. That not killed is soft and light in weight and apparently deficient in stored plant food. The difficulty of obtaining good fruiting wood for the succeeding year becomes a serious problem.

As the appearance of this sick condition was first associated with the Chlorosis of the Vinifera in France, the accepted remedial measures of that country were tried, namely the application of sulphate of iron to the

soil, and with water, as a spray. Three years experiments along these lines failed to yield beneficial results.

That the trouble is connected in some way with the relationship of roots to the soil is evident from the fact, that those vines observed as the worst affected, extended diagonally across a knoll, and in each row the vines were affected for only a short distance either side of it. The soil over this knoll, both soil and subsoil, was compared with that from other parts of the same vineyard, and where the vines were unaffected. That over the knoll on which the sick vines were located, proved to be of much finer texture, of a more silty nature and more deficient in organic matter than in other parts. Chemical analyses of the two revealed no striking differences in nitrogen, phosphorus, potassium or calcium carbonate content. In two other vineyards the subsoil is very similar to that just described and the trouble was proportionate to the percentage of yellow silt present. In the case of the 23-years-old vineyard these soil differences were not seen. In a part of another young vineyard the subsoil was black silt. Here the soil remained wet throughout the growing season by reason of underground seepage water. However considering all the diseased vines, the greater percentage was located on yellow silt soil.

Thus far applications of nitrogen in nitrate of soda and dried blood, potassium in the form of sulphate and muriate of potash, phosphorus in acid phosphate and basic slag, sodium sulphate, calcium oxid or calcium carbonate have not affected the degree of the affection.

In 1912, the year that this trouble was observed in the 23-years-old vineyard, located on the deep gravelly loam soil already mentioned, the first valuable data were obtained as to the probable influence that favored the sickly condition. Since 1909 four plats of two rows each, have been sown, during late July each year, to a green manure crop of mammoth clover. This was plowed under the following spring. In 1913 it was decided to allow the clover in two of these plats, one limed the other not, to grow during the summer and to mow at intervals, leaving the mowings as a mulch. The summer of 1912 was very dry. For twenty-seven days previous to July 13 no rain occurred. On this day 0.41 inches fell. Some days previous to this rainfall the vines in the clover mulched plats began showing symptoms of disease and this developed into the worst case that had yet been seen. Vines in a depression of the rows were not so badly affected as were those on the slopes at either side. The rows immediately bounding the clover rows showed negligible amounts of the disease and there was practically none in the remainder of the vineyard. No differences were discernible between the limed and unlimed plats, while the vines in the two other plats in which clover had been plowed under in the spring were healthy. The fruit from the diseased clover plats was char-

acteristic of that examined from the other vineyards in previous years. In 1913 these vines showed the effect of the trouble from the previous year, but in 1914 they were normal healthy vines and equal to the others.

Considering the data at hand it would seem that a lack of moisture in the soil or the inability of the vines previously affected to absorb the optimum amount is the underlying cause of the trouble. The yellow silt soil, being deficient in organic matter, is not able to retain the moisture in sufficient amounts to balance the loss through transpiration, and the loss through evaporation. Especially is this true in extreme drouths. It has been mentioned earlier that the affection appears to be cumulative and this would naturally follow, as the leaves become functionless, fibrous growth of the root system is checked, hence lessened absorbing surface for the following year. In the case of the vines of the clover plats, the fact that the trouble was not observed previous to 1912 and that it has not recurred would indicate that the growing clover roots utilized the soil moisture to the detriment of the vine, while the amount of the mulch was not sufficient to check evaporation from the surface. Had the season not been one of drouth, it would seem consistent to believe no such ill effects would have been noted. The fact that the affection was considerably less in a depression where the water accumulated would tend to bear out this belief.

In the vineyard located on black silt, fed by subterranean springs over which the soil was wet throughout the summer, it is believed that excessive moisture prevented the development of root systems commensurate with the needs above ground. Examination of the root system of affected vines as compared with nearby healthy ones of the same age and variety showed a marked deficiency of fibrous roots in the former, and also a number of main roots already dead. It is known that vines growing on wet soils do not make a normal amount of root growth. With this vineyard lack of aeration may contribute to the trouble. This land was recently tile drained and while there is a steady discharge throughout the summer, a large part of it is probably due to the interception of an underground water course. In later years when the soil becomes more porous as a result of the tiling, the affection should diminish, if it be due to a curtailment of moisture supplied to the aerial parts.

Reports and observations of other vineyards indicate that the trouble is not uncommon. Invariably it is found under situations similar to those mentioned. Also it is more common with young vines. This latter can be accounted for from the fact that the root system of newly planted vines are not extensive enough to afford ample absorbing surface. Older vines with deeply penetrating roots, hence are able to better withstand drouth. Any practice that results in the accumulation of humus in the soil suggests

itself as a possible relief. With soils that do not allow sufficient root development, by reason of wetness, thorough tile drainage seems to be the logical solution. Under such conditions a certain amount of injury will result for several years but the degree will depend to a considerable extent upon the summer rainfall and the thoroughness with which this is conserved. Conservative pruning will in considerable degree relieve, through lessening the amount of fruit to be matured.

VINEYARD LABORATORY

NEW YORK AGRICULTURAL EXPERIMENT STATION

FREDONIA, N. Y.

NOTES ON SOME DISEASES OF TREES IN OUR NATIONAL FORESTS. V

GEORGE GRANT HEDGCOCK

This paper is a continuation of notes¹ on forest tree diseases based on observations and collections made chiefly by the writer, assisted by Dr. E. P. Meinecke, Dr. Jas. R. Weir, Dr. Perley Spaulding, Mr. W. H. Long, Mr. Carl Hartley, Mr. G. F. Gravatt, and Mr. J. F. Rogers, of the Office of Investigations in Forest Pathology during a survey of the diseases in the forests of the United States.

SPECIES OF RAZOUMOFSKYA (ARCEUTHOBIMUM) ATTACKING GYMNOSPERMS

1. *Razoumofskya pusilla* (Peck) Kuntze occurs on the following species in the northeastern United States: it very commonly attacks the black spruce, *Picea mariana*,² and less frequently the white spruce,² *Picea canadensis*, the red spruce, *Picea rubens*, and the eastern larch, *Larix americana*. A larger form of *Razoumofskya*, which probably does not belong to this species, is described by Engelmann³ as *Arceuthobium douglasii* var. *microcarpa*. This form occasionally is found on the Engelmann spruce, *Picea engelmanni*, in Idaho, Colorado, Arizona, and New Mexico, the blue spruce, *Picea parryana*, in New Mexico, and the weeping spruce, *Picea breweriana* in California.

2. *Razoumofskya douglasii* (Engelm.) Kuntze very commonly attacks the Douglas fir, *Pseudotsuga taxifolia*, throughout the range of this tree from the Rocky Mountains to the Pacific Coast, and from the Mexican boundary to the Dominion of Canada.

3. *Razoumofskya americana* (Nutt.) Kuntze is very common on the lodge-pole pine, *Pinus contorta*, throughout the range of this species of tree, especially in the central and northern Rocky Mountain region and on the eastern slopes of the Sierra Nevadas in California and Oregon.

¹ Notes on some diseases of trees in our national forests: I, Printed privately at Washington, D. C., February, 1914; II, *Phytopathology* 2: 73-80. April, 1912; III, *Phytopathology* 3: 111-114. April, 1913; IV, *Phytopathology* 4: 181-188. June, 1914.

² The nomenclature for trees in this paper is that of Geo. B. Sudworth, U. S. Dept. Agr., Bur. For. Bul. 17. 1898, and *Forest Trees of the Pacific Slope*, For. Serv. 1908.

³ U. S. Geol. Surv. west of 100th Merid. (Wheeler's Rept.) Bot. 6: 253. 1878.

4. *Razoumofskya cryptopoda* (Engelm.) Coville the eastern form of the following species is very common on the western Yellow pines, *Pinus ponderosa*, and *Pinus ponderosa scopulorum*, in the states in the region of the Great Basin and Rocky Mountains from eastern Washington to New Mexico. In New Mexico and Arizona, this mistletoe or a closely related species, attacks the Chihuahua pine, *Pinus chihuahuana*, and Mayr's pine, *Pinus mayriana*.

5. *Razoumofskya campylopoda* (Engelm.) Piper occurs very commonly on *Pinus ponderosa* in the Pacific Coast region. It or closely related species attacks Jeffrey's pine, *Pinus jeffreyi*, the Monterey pine, *Pinus radiata*, the Sabine pine, *Pinus sabiniana*, and Coulter's pine, *Pinus coulteri*, in California.

6. *Razoumofskya divaricata* (Engelm.) Coville occurs frequently on the nut pines. *Pinus edulis* is attacked from Colorado, Utah, and California southward to Mexico, and *Pinus monophylla* in Arizona and California. The knob-cone pine, *Pinus attenuata*, is occasionally attacked in California by a form of *Razoumofskya* which may belong here.

7. *Razoumofskya laricis* Piper often attacks the western larch, *Larix occidentalis*, in Montana, Idaho, Washington, and Oregon. It is occasionally found on Lyall's larch, *Larix laricina*, in Idaho.

8. *Razoumofskya tsugensis* Rosend, is frequently found in the north-western United States from Montana to Washington on the western hemlock, *Tsuga heterophylla*, and occasionally in Washington on Merten's hemlock, *Tsuga mertensiana*.

9. *Razoumofskya douglasii abietina* (Engelm.) Piper, the smaller form of dwarf mistletoe on species of *Abies*, occasionally attacks the cork fir, *Abies arizonica*, in Arizona and New Mexico. It is common on the white fir, *Abies concolor*, from Arizona northward to Oregon; on the grand fir, *Abies grandis*, from California to Washington and Idaho; on the red fir, *Abies magnifica*, and on the Shasta fir, *Abies shastensis*, in California; on the noble fir, *Abies nobilis*, and the Amabilis fir, *Abies amabilis*, in Washington; and on the alpine fir, *Abies lasiocarpa*, from Colorado to Montana.

10. *Razoumofskya occidentalis abietina* (Engelm.) Coville, the larger form of dwarf mistletoe on species of *Abies*, is frequently found in Utah, California and Oregon on *Abies concolor*; and in California and Oregon on *Abies grandis* and *Abies magnifica*.

11. *Razoumofskya cyanocarpa* (A. Nelson) Rydberg, occasionally attacks the limber pine, *Pinus flexilis*, from Colorado to Montana; the white-barked pine, *Pinus albicaulis*, in Idaho and Montana; and the bristle-cone pine, *Pinus aristata*, in Utah and California. This mistletoe, or a closely related species, attacks the mountain white pine, *Pinus monticola*, in California; the sugar pine, *Pinus lambertiana*, in California and Oregon; and the Mexican white pine, *Pinus strobiformis*, in Arizona.

THE EFFECT OF PLANTS OF SPECIES OF RAZOUMOFSKYA ON THEIR HOSTS

All these species of *Razoumofskya* retard the growth of the trees they attack. This results from an excessive growth of the portion of the tree attacked whether it be a twig, a limb, or the trunk itself. The immediate effect on the host in the region of a primary infection by *Razoumofskya* is to cause hypertrophy in the cambium of the wood tissues which form in the vicinity of the sinkers or roots of the young mistletoe plants. This produces usually a fusiform swelling. Later the spread of the sinkers of the mistletoe throughout the branches of an affected limb stimulates an increased production of twigs, and the formation of a witches broom. The form of this broom varies with the habit of growth of the limbs and twigs of species of tree attacked. These witches brooms often develop to an immense size, and at the same time their increased vigor decreases that of all other portions of the tree. This materially lessens the annual increment to the wood in the trunk.

Some species of dwarf mistletoes in the northwestern United States, for example, *Razoumofskya laricis*, and *R. tsugensis*, form dense witches brooms, composed of very brittle limbs and twigs. The weight of heavy snows on the brooms, cause them to break, usually near the point of attachment. This lessens the amount of foliage on the trees and directly retards their growth. At the same time a wound is made at the point of rupture which enables heartrotting fungi, such as *Trametes pini* (Brot.) Fr. and *Echinodontium tinctorium*, E. & E. to gain an entrance into the heartwood of the limb of the trees. These two species of fungi alone are responsible for an enormous loss in values in our older forests in the western United States.

Plants of these species of *Razoumofskya* or dwarf mistletoes are so abundant in many localities that from 25 to 50 per cent of the trees are attacked. The resulting loss in tree growth is consequently enormous, and the problem of eradicating these mistletoes becomes one of prime importance in forest hygiene.

SPECIES OF PHORADENDRON ATTACKING ANGIOSPERMS

1. *Phoradendron flavescens* Nutt., a polymorphic species, attacks many broad-leaved trees, and occasionally shrubs, in the eastern, southeastern and southern United States. It has several quite distinct forms. The following are the principal ones: a large obovate-leaved form, with the largest white berries of any species, is common on red maple, star-leaved gum, black locust, black walnut, elm, and other species in the eastern, southeastern, and southern United States; an orbicular-leaved form with smaller whitish berries occurs chiefly on oaks in the southern United

States: a narrow-leaved form with white berries is found in Florida on oaks, ash and other species.

Phoradendron flavescens in its eastern forms has been either reported or collected on the following host species: *Acacia roemeriana*, *Acer rubrum*, *A. saccharinum*, *Aesculus glabra*, *Betula nigra*, *Benzoin aestivalis*, *Castanea dentata*, *Celtis occidentalis*, *C. mississippiensis*, *Crataegus* sp., *Diospyros virginiana*, *Fagus atropunicea*, *Fraxinus americana*, *F. berlandieriana*, *F. caroliniana*, *Hicoria cordifolia*, *H. pecan*, *H. glabra*, *H. ovata*, *Gleditsia aquatica*, *G. triacanthos*, *Juglans nigra*, *Liquidambar styraciflua*, *Melia azedarach*, *Nyssa sylvatica*, *Papyrus papyrifera*, *Platanus occidentalis*, *Populus deltoides*, *Prosopis juliflora*, *Prunus angustifolia*, *P. cerasus*, *P. serotina*, *Pyrus communis*, *P. malus*, *Quercus alba*, *Q. brevifolia*, *Q. catesbii*, *Q. chapmani*, *Q. digitata*, *Q. georgiana*, *Q. lyrata*, *Q. macrocarpa*, *Q. marilandica*, *Q. minor*, *Q. nigra*, *Q. palustris*, *Q. phellos*, *Q. texana*, *Q. velutina*, *Q. virginiana*, *Robinia pseudacacia*, *Salix amygdaloides*, *Salix nigra*, *Sapindus marginatus*, *Sophora secundiflora*, *Toxylon pomiferum*, *Tecoma radicans*, *Tilia floridana*, *Ulmus americana*, *U. crassifolia*, *U. pubescens*, and *Xanthoxylum clava-herculis*. The oak and ash trees in southeastern United States are often attacked by the narrow-leaved form. From Oklahoma to Texas the orbicular or round-leaved form, *Phoradendron flavescens orbiculatum* Engelm., is common on oaks.

2. *Phoradendron flavescens macrophyllum* Engelm. is represented in Arizona and New Mexico by two or three large-leaved forms with three- to five-nerved leaves and with white berries which are smaller than those of *Phoradendron flavescens* on gum, maple, and other trees in the eastern United States. It attacks the following species of trees: *Alnus oblongifolia*, *Fraxinus americana*, *F. cuspidata*, *F. velutina*, *Juglans rupestris*, *Platanus wrightii*, *Populus angustifolia*, *P. deltoides*, *P. fremontii*, *Prunus* sp., *Prosopis odorata*, *Pyrus communis*, *P. malus*, *Robinia pseudacacia*, *Salix nigra*, *S. taxifolia*, and *Sapindus marginatus*.

A smaller, round-leaved form with small greenish-white berries, related to *Phoradendron flavescens orbiculatum* Engelm., occurs in Arizona, New Mexico, and extreme western Texas. It has been either collected or reported on the following trees: *Quercus arizonica*, *Q. chrysolepis*, *Q. emoryi*, *Q. gambelii*, *Q. hypoleuca*, *Q. oblongifolia*, *Q. reticulata*, and *Q. toumeyii*.

In California and Oregon there is a somewhat variable form of *Phoradendron flavescens*, which has large leaves, usually five-nerved, and greenish-white to white berries. This form corresponds to *Phoradendron flavescens macrophyllum* in Arizona and New Mexico but probably is not identical with it. This form has been noted in California on the following host species: *Alnus rhombifolia*, *Platanus racemosa*, *Populus trichocarpa*, *P. nigra*, *Pyrus communis*, *P. malus*, *Robinia pseudacacia*, and *Salix nigra*.

3. *Phoradendron villosum* Nutt. is a species found in California and Oregon, which is related to *Phoradendron flavescens* but distinct from it. It has more or less rounded leaves, small white or pink berries, and is related to *Phoradendron flavescens orbiculatum* Engelm. It is known to attack most commonly various species of oaks. It has either been collected or reported on the following host species: *Aesculus californica*, *Arctostaphylos manzanita*, *Forestessia neo-mexicana*, *Quercus agrifolia*, *Q. californica*, *Q. chrysolepsis*, *Q. douglasii*, *Q. garryana*, *Q. lobata*, *Q. wislizeni*, and *Rhus diversiloba*.

4. *Phoradendron californicum* Nutt., a leafless species with long stems and pink berries, attacks a number of species of trees in the southwestern United States from Texas to California. It has been either collected or reported on the following host species: *Acacia greggii*, *Cercidium torreyanum*, *Condalia spathulata*, *Covillea tridentata*, *Dalea spinosa*, *Oleña tesota*, *Parkinsonia microphylla*, *Prosopis juliflora*, and *P. odorata*.

SPECIES OF PHORADENDRON ATTACKING GYMNOSPERMS

1. *Phoradendron pauciflorum*, Torr., a polymorphic species which has also been called *Phoradendron bolleanum* Eichl. is found in the southwestern and western United States. There are at least two distinct forms of this mistletoe. All forms have pink berries, and leaves varying in shape from spatulate to linear. A form, evidently a distinct species with linear, villose leaves, attacks species of Juniper. It has been found on *Juniperus occidentalis*, and *J. utahensis*. Three spatulate-leave forms of *Phoradendron* which evidently differ in species from the previous are known, one on *Abies concolor*, a second on *Cupressus arizonica*, *C. glabra* and *C. macnabiana*, and a third on *Juniperus californica*, *J. monosperma*, *J. occidentalis*, and *J. pachyphloea*. Dr. Meinecke reports a white-berried, spatulate-leaved form on *Cupressus sargentii*.

2. *Phoradendron juniperinum* Engelm. attacks nearly all species of Junipers in the southwestern and western United States, ranging from New Mexico and Colorado to California and Oregon. The leaves of this species are mere scales and its berries are pink to pinkish-yellow. It attacks *Juniperus californica*, *J. monosperma*, *J. occidentalis*, *J. pachyphloea*, *J. scopulorum*, and *J. utahensis*. It has been reported on *Cupressus arizonica* and *Pinus monophylla*, but neither the writer nor any other member of this Office has seen specimens of this species of *Phoradendron* on *Cupressus* or *Pinus*. This species also attacks *Libocedrus decurrens* in California and Oregon, on which host it is known as *Phoradendron juniperinum libocedri* Engelm., but the writer doubts if this is a good variety because it is similar to the form on *Juniperus*.

THE EFFECT OF PLANTS OF SPECIES OF PHORADENDRON ON THEIR HOSTS

One or more species of *Phoradendron* may be found in great abundance in many localities in the southern, southwestern, and western United States. The loss due to the effects of *Phoradendron* in lessening tree-growth in the United States is less than that caused by *Razoumofskya*, nevertheless it is apt to be underestimated.

The increased chlorophyll-bearing surface in the leaves and stems of plants of species of *Phoradendron*, naturally makes them less dependent on the host for a supply of carbohydrates, and as a result they must exert a less deleterious effect, since they require chiefly a supply of water and mineral foods. In this regard they might be compared to plants rooted in soil. On the other hand the water they receive is in the form of sap from the host and it naturally follows that it contains in addition to water all the necessary food constituents required by the host. The *Phoradendron* plant although it does build up carbohydrates, apparently uses some of the supply furnished by the host. The amount used by the parasite depends upon the relative amount of chlorophyll-bearing surface it possesses. This may be relatively large as in forms of *Phoradendron flavescens*, or relatively small as in case of *Phoradendron californicum*, and *P. juniperinum*, where the chlorophyll is confined almost exclusively to the stems.

Plants of species of *Phoradendron* exert a stimulus upon the cambium tissues of the host at the point of their attachment. This frequently causes very marked hypertrophy locally. These hypertrophied areas or burls are especially prominent in trees of *Abies concolor* when attacked by *Phoradendron pauciflorum*. The grain of the wood in these burls or galls is much distorted, and as a result the tensile strength of the wood is lessened. Finally the tree is often broken off by winds at the point where these burls are formed. Burls are found to some extent in case of other conifers attacked by *Phoradendron*.

In case of species of *Abies*, *Cupressus* and *Juniperus*, it is often noted that the *Phoradendron* plant diverts the growth of the limb at the point of attack, so much that the limb and its branches are starved and killed from this point outward. This leaves the limb without branches, and in their stead a living *Phoradendron* plant borne at the resulting apex. In Arizona and New Mexico, *Juniper* trees are often found where *Phoradendron juniperinum* has taken complete possession of a number of the more important limbs of the tree. In all such cases the growth of the host either is almost entirely checked or greatly retarded. Similar instances occur in trees of many broad-leaved species when attacked by *Phoradendron californicum*, *P. villosum*, and *P. flavescens* or its varieties.

In no instance has it been observed that *Phoradendron* plants exert a beneficial effect on the host, but on the contrary the injury caused by their presence appears to be in direct proportion to the relative increase in number and size of the *Phoradendron* plants on any given tree. This has been noted especially in case of ornamental and shade trees in cities and towns of the southern and western United States.

The injurious effect of plants of species of *Phoradendron* and *Razoumofskya* on trees can no longer be doubted. Apart from sentiment, there can be no reason for permitting them to remain on shade and ornamental trees, and in the forests all well-matured plans for scientific forest management should include the cutting of all trees diseased by mistletoes whenever practicable, especially when an area is lumbered. Where seed trees are left in such areas, care should be taken to select those that are not diseased by mistletoes in order to prevent the spread of these parasites to the trees of the younger generations of the forest.

OFFICE OF INVESTIGATIONS IN FOREST PATHOLOGY

U. S. DEPARTMENT OF AGRICULTURE

WASHINGTON, D. C.

A NEW MACROPHOMA ON GALLS OF POPULUS TRICHOCARPA

ERNEST E. HUBERT

WITH THREE FIGURES IN THE TEXT

In the fall of 1909 a collection of very noticeable galls occurring on *Populus trichocarpa* Torr. & Gr. was made with the supposition that they were caused by an insect, *Saperda populnea* L. Upon examination, the galls showed no evidence of insect origin as was supposed, and sections were made to determine, if possible, the cause of the hypertrophy. The first attempt along this line proved fruitless, for too little attention was paid the condition of the bark. In March, 1910, another collection was made for further study.

Thin transverse sections of the galls taken from the older twigs of an infected tree and stained with eosin disclosed large subcarbonous, pycnidia in great numbers embedded in the cortex. These pycnidia were filled with numerous, elongate, hyaline spores borne on short simple sporophores arising from a mycelial layer directly above the hypothecium. These spores filled the cavity of the fruiting body and escaped through the ostiole in coiled, thread-like masses. Upon placing a few of the spores in sugar solution and in a solution of the extract from *Populus* twigs, it was found that they germinated readily in both media, producing hyphae similar to those which were found extending downward from the pycnidia into the host tissue. It might be well to mention here that the pycnidia were not found upon the normal stems, branches or twigs.

Subsequently, experiments were started to determine whether the fungus in question caused the hypertrophy of the twigs and branches or whether the abnormal growth could be traced to other causes. An attempt was also made to locate the ascogenous stage of the parasite. So far, examinations of old galls have revealed nothing but the pycnidial stage.

The fungus was identified as a species of *Macrophoma* but its specific identity could not be determined.

In November, 1914, samples of the galls were sent to Dr. C. L. Shear, of the Bureau of Plant Industry, who determined the fungus to be an undescribed species of *Macrophoma* and named it *Macrophoma tumefaciens* n. sp. Shear's description of the cottonwood-gall fungus follows:

***Macrophoma tumefaciens* Shear n. sp.**

Pycnidia numerous, depressed, globose, buried in the cortex, subcarbonaceous, irregular in shape, slightly erumpent, subepidermal, 120 to 350 μ in diameter; ostiole slightly elevated, non-papillate; pore small, dark-colored; pycnosporos elongate, subellipsoid to subrhomboid, frequently irregular in outline and inequilateral, mostly obtuse, hyaline to pale lemon yellow, 24 to 40 $\mu \times 7.5$ to 12 μ , ejected in coiled thread-like masses, contents granu-



FIG. 1. *Populus trichocarpa*, showing the numerous galls upon branches and twigs. Photograph reproduced by courtesy of J. R. Weir.

lar; germinating readily and producing dark-brown, thick-walled hyphae; sporophores 6 to 12 μ long, simple, filamentous; hyphae dark brown, septate, 10 to 12 μ wide; cell wall 1 to 1.5 μ thick.

Habitat: On gall-like swellings of branches and twigs, *Populus trichocarpa*, Missoula, Montana, November, 1914, Ernest E. Hubert.

Type specimen: No. 2808, Pathological Collections, Bureau of Plant Industry, Washington, D. C.

Co-type No. 121Y in the collection of E. E. Hubert.

Cross inoculations and cultural experiments are well under way but no definite results can be given at present. A later paper is intended to be published dealing with the pathological relations of the fungus to the host, and an attempt will be made to produce in cultures or to locate in nature the perfect stage.

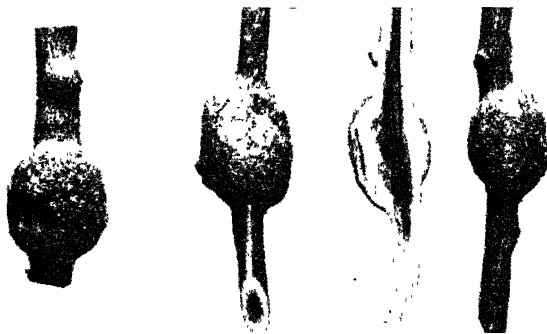


FIG. 2. Galls from *Populus trichocarpa*. The specimen at the left shows a young gall forming just above an old one. Reduced one-half.

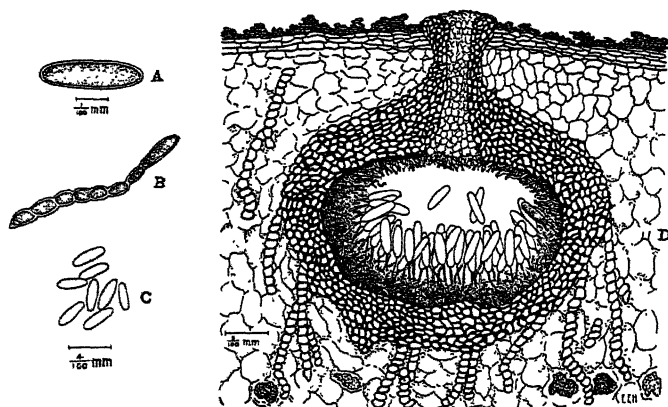


FIG. 3. *Macrophoma tumefaciens*. *a*, pycnosporangium showing granular contents; *b*, pycnosporangium germinating; *c*, pycnosporangia showing variations in size; *d*, pycnidium embedded in tissue of *Populus trichocarpa* gall. Note hyphae extending downward into tissue of host.

These galls with the accompanying fungus are widely distributed through Montana, occurring principally upon twigs and branches of *Populus trichocarpa*. Collections and observations were made in Montana at Missoula, Ralston, Philipsburg, Florence, Drummond, Custer, Bearmouth, Deerlodge, and Wisdom; in Idaho, at Eagle, Avery, and St. Maries.

The galls appear almost invariably at the point where the twigs and branches fork. Those occurring at the base of young twigs have a tendency to cause that portion of the twig, in advance of the gall, to become dwarfed and finally to die. The galls are so numerous on some of the older trees that a greater portion of the lower branches appear to have been killed by them. Young trees in the near vicinity of an old infected tree also bear the same galls upon twigs and branches and show evidence of the injurious presence of these growths.

Since the gall formation can not be traced to insect work, it is reasonable to suppose that the hypertrophy is caused by the hyphae of the fungus, *Macrophoma tumefaciens*, extending into the growing tissues and stimulating them to unusual activity. At any rate the injury to the infected tree is great enough to merit investigation as to the primal cause of the disorder.

MISSOULA

MONTANA

A PRELIMINARY STUDY OF ERGOT OF WILD RICE

FAITH FYLES

WITH PLATE XI

In my experiments with the cultivation of Canadian wild rice, *Zizania aquatica* L. & *Z. palustris* L., I had often noticed ergot among the seed. A search of the literature revealed only one record of the occurrence of ergot on wild rice (R. H. Denniston (1)).

The questions arose, first, is this ergot identical with the typical ergot (*Spermoedia clavus* (D. C.) Fries), of rye, second, will cereals and other grasses growing in its neighborhood be in danger of infection by it?

Dr. Robert Staeger (2) of Bern, Switzerland, who has been successfully experimenting with ergot of rye for many years, has already proved that ergot, which cannot be distinguished morphologically, may, however, require quite a different range of host plants. He has shown by a series of successful experiments that ergot of rye, *Secale cereale*, will infect the following grasses:

Anthoxanthum odoratum, *Hierochloe odorata*, *Poa pratensis*, *Phalaris arundinacea*, *Arrhenatherum elatius*, *Dactylis glomerata*, *Poa sudetica*, *Festuca pratensis*, *Festuca arundinacea*, Barley, *Hordeum murinum*, *Alopecurus pratensis*, *Briza media*, *Poa hybrida*, *Poa compressa*, *Calamagrostis arundinacea*, *Bromus sterilis*, *Secale cereale*, Spanischer Doppelroggen.

He has further shown that *Claviceps microcephala* Tul., (now *Spermoedia microcephala* (Wallr.) Seaver) of which the typical host plant is *Phragmites communis* Trin., does not exist on a single host plant subject to attacks of *Spermoedia clavus* (D. C.) Fries. *S. microcephala* infects, he states, besides its host, *Nardus stricta*, *Molinia coerulea*, and *Aira caespitosa*.

I secured a small quantity of fresh wild rice seed, gathered at Treadwell, Ontario, September 29, 1913. Among the seed were many ergots, several of which were still within the glumes of the wild rice. On October 9, 1913, most of these sclerotia were placed in pots of sand outside the laboratory window. Occasionally they were watered until they became buried in snow. Others of the same lot of sclerotia were placed in sterilized sand and water in two stender dishes kept in the laboratory at some distance from the window. They were given water twice, once in November and once in December. On December 16, two sclerotia had already germinated. One sclerotium had 19 stromata from 1 to 5 mm. high and the

other showed 11 stromata. Judging from later observations, germination must have taken place a week or ten days before, i.e., a little over two months after the sclerotia were gathered. Although these ergots had been kept at room temperature from September 29, they had already, in the open air, been subjected to 2° frost on September 16, 1913.

The ostiola of the perithecia appeared in the form of minute dots on December 22 when the stromata were only 7 mm. high and the heads 1 mm. in diameter. They gradually became more distinct as the perithecia protruded until finally the stromata looked like diminutive spiked clubs. The first spores were seen on December 30. There were 40 stromata at one time on this sclerotium, the most mature being 2.5 cm. high with a head 2.5 mm. wide, while the youngest could just be seen through a crack in the cortex. One other ergot of this sowing produced 40 stromata and a third 37. The remainder did not germinate so freely, the last showing only 10 heads. Of later sowings, the greatest number of heads on a single intact ergot was 48, and the least 11. Broken pieces of ergots produced from 3 to 7 stromata. The heads were light buff in color with lavender stalks, becoming deeper and slightly reddish with age. At the height of maturity, the perithecial chambers measured 250 to 325 μ in length and 150 to 160 μ in width. The asci were 200 to 215 μ long and about 4 μ wide. The spores were 150 to 180 μ long.

On reading H. T. Güssow's account (3) of tri-septate spores recorded in his ergot of barley, I examined the spores of my fungus and am able to confirm his finding of three septa in each spore, which evidently indicates a generic character.

As wild rice is essentially an aquatic plant and naturally most of the ergots would drop into the water to float away or be washed ashore, more sowings were made: In unsterilized sand and water; unsterilized mud and water and in distilled water alone. In the first experiment, the sclerotia germinated abundantly and produced strong and healthy heads. Those in mud and water with about 2 mm. of water above the mud flourished also, and grew 4.5 to 5 cm. high with heads 2.5 mm. wide. Those floating on the distilled water germinated freely on all sides of the sclerotia, but their growth was slow, and, when they were only 5 mm. high, they became covered with mould fungi. The mould was removed as far as possible, and the sclerotia were transferred to sterilized sand and water. A few of these stromata finally produced spores, but most of them perished before maturity.

In all these sowings, most of the ergots were placed merely on top of the sand or mud. A few were buried an inch or more, but not one of the latter germinated. Even those which were brought to the surface after being buried three months did not show signs of life.

On May 22, 1914, the last of the number of sclerotia, which had been left exposed all winter outside were divided; one-half was brought into the laboratory and the other half left in a box of mud and water beside the growing wild rice. On June 30, when those in the laboratory had almost finished their spore-shedding and were 4 to 4.5 cm. high, those outside had just begun to shed their spores. This was before the rice had shown any signs of blooming. The growth was very thick and short—only 1 cm. high with heads 3 to 3.5 mm. in diameter and of a dark reddish purple color, indicating the strong positive heliotropism to which *Claviceps* is known to be subject.

The following table gives the data of the different stages of growth taken from one or two sclerotia of each sowing; all harvested in September, 1913.

INFECTION EXPERIMENTS WITH ERGOT OF WILD RICE

At the time of the first sowing of ergot of wild rice, October 9, 1913, we had just received a small barrel of wet wild rice seed of the autumn's gathering. In this were found a dozen seeds or more that had already germinated. As this autumnal germination of wild rice is very unusual, the young seedlings were carefully planted in large glass jars with 15 cm. of mud. The jars were then filled with water and placed, some in the laboratory and some in the greenhouse for infection experiments. Later, twelve pots of rye and barley were sown for the same purpose. But the wild rice grew slowly in the winter and the barley and rye did not make the desired progress. It was necessary to make repeated sowings of ergot all through the winter in order to have on hand mature stromata when the grasses bloomed. When, at last, the first stalks of rye and barley were in bloom, the spore-shedding of one entire lot of ergot was over and the next lot was not yet mature.

Unfortunately, at that time, I had not read Dr. Staeger's (4) recent work on infection experiments with ergot of rye, in which he showed that the conidia still adhering to the wintered sclerotia of ergot of rye were capable of germination and infection even after ten months' rest. On reading this paper, I at once re-examined the ergot, which had been kept dry in a stoppered glass jar, and found several ergots with a whitish coating, some of which were still within the glumes of the wild rice. The glumes were carefully removed and a dry white substance was found at the base of the ergots as well as inside the glumes. These ergots and glumes were soaked in distilled water for a few minutes. The water at once became milky; a drop under the microscope proved it to be full of conidia.

TABLE 1
The development of sclerotia harvested September 1913

DATE OF PLANTING		FIRST APPEARANCE OF STROMATA	FIRST APPEARANCE OF PERITHECIA	HEIGHT AT THAT TIME	FIRST EMERGENCE OF SPORES	HEIGHT AT THAT TIME	NO. OF STROMATA ON THE SCLEROTIUM	GREATEST HEIGHT OF STROMATA
				millimeters		millimeters		millimeters
1913		1913						
Oct. 9	Sterilized sand and water	Dec. 10	Dec. 22	7	Dec. 30	20	40	25
Oct. 9	Sterilized sand and water	Dec. 18	Dec. 22	10	Dec. 31	29	37	30
Oct. 9	Sterilized sand and water	Dec. 18	Dec. 23	12	Jan. 2	20	40	23
		1914						
Oct. 9	Sterilized sand and water	Feb. 4	Feb. 14	15	Feb. 20	25	15	28
Oct. 9	Sterilized sand and water	Feb. 4	Feb. 14	15	Feb. 26	23	10	23
		1913						
Dec. 16	Sterilized sand and water	Dec. 23	Jan. 2	10	Jan. 7	12	27	15
Dec. 16	Sterilized sand and water	Dec. 23	Jan. 2	10	Jan. 8	12	23	20
Dec. 16	Sterilized sand and water	Dec. 23	Jan. 11	15	Jan. 15	20	25	21
		1914						
Dec. 16	Sterilized sand and water	Mar. 6	Mar. 16	8	Mar. 24	10	26	15
Dec. 16	Sterilized sand and water	Mar. 6	Mar. 18	12	Mar. 28	14	25	21
Dec. 17	Unsterilized mud and water	Jan. 5	Jan. 13	8	Jan. 19	20	36	45
Dec. 17	Unsterilized mud and water	Jan. 5	Jan. 20	13	Jan. 25	27	29	50
		1913						
Dec. 17	Unsterilized sand and water	Dec. 31	Jan. 13	5	Jan. 22	24	22	40
		1914						
Jan. 3	Sterilized sand and water	Feb. 2	Feb. 13	10	Feb. 19	15	38	20
Jan. 3	Sterilized sand and water	Feb. 4	Feb. 16	11	Feb. 26	17	15	24
Feb. 20	Sterilized sand and water	Mar. 14	Mar. 31	10	Apr. 14	17	48	20
Feb. 20	Sterilized sand and water	Mar. 17	Mar. 31	9	Apr. 13	15	34	18
Feb. 20	Sterilized sand and water	Mar. 18	Apr. 2	9	Apr. 11	10	46	15
Mar. 28	Sterilized sand and water	Apr. 14	Apr. 30	10	May 4	13	14	10
Mar. 28	Sterilized sand and water	Apr. 17	May 2	10	May 6	14	11	17
May 4	Sterilized sand and water	May 23	June 2	10	June 10	23	40	30
May 4	Sterilized sand and water	May 25	June 3	10	June 11	23	40	30
May 4	Sterilized sand and water	May 27	June 3	10	June 12	25	23	35

First inoculation of barley and rye

The barley and rye spikes, which were then at anthesis as well as those a little past this stage, and others in which the kernel had begun to form, were all inoculated with this spore-containing solution on April 24, 1914. No honeydew appeared on any of them, not even after a month. Only healthy seeds were seen on the now ripened heads.

First inoculation of wild rice

In the meantime, the wild rice in the greenhouse had bloomed. In the afternoon of May 11, fresh ascospores of the ergot were caught in water and sprinkled on the pistillate flowers of one stalk of wild rice, pollinated that morning. On May 15, the flowers were still very fresh, and, fearing they had been inoculated too soon and determined to obtain some positive result from this experiment, I re-inoculated them, both with fresh ascospores and with conidia obtained from the wintered ergots. Thus, when honeydew did appear, it was uncertain whether the conidia or ascospores were the cause of it. On the morning of May 30, 1914, two large drops of honeydew were found on this stalk of wild rice. A little of it in a drop of water was examined under the microscope, and found to be full of conidia. They measured 9 to 12 μ in length and 2.5 to 3.5 μ in width. (Those of *S. clavus* are 7 μ in length and 3.5 μ in width.)

On June 1, there were four drops of honeydew. The lowest drop, which was the first to appear, had changed somewhat in appearance, being now less clear and more viscid. On June 3, there were unmistakable signs of two purplish sclerotia. June 6, honeydew had ceased oozing, and three large and firm sclerotia were seen. June 11, as the sclerotia and also the plant seemed to be drying prematurely, the stalk bearing the ergots was cut off to preserve it. A little of the fresh honeydew had previously been secured in a small bottle.

Second inoculation of wild rice

On June 1, 1914, a second jar of wild rice in another wing of the greenhouse bloomed for the first time. This was inoculated with the spore-containing water of the dry ergots of September 1913.

On June 11, a drop of honeydew appeared on the uppermost flower and in two days the beginnings of a sclerotium were visible. On June 17, a lower flower also showed honeydew. The success of this second infection experiment with wild rice, which had only been inoculated with last year's conidia, proves that the conidia are still capable of germination even after nine months' rest, which confirms De Steeger's discovery in regard to the ergot of rye.

EXPERIMENTS WITH RYE AND OTHER HOSTS OF ERGOT OF RYE

The rye plants, which were inoculated at the same time as the wild rice, i.e., May 11, 1914, with fresh ascospores and May 15, with old conidia, still showed no signs of honeydew.

On May 30, when honeydew first appeared on wild rice, a little of it was used to inoculate the last pot of rye in bloom. With some more of this same fresh honeydew, on June 6, the following grasses, which had been brought in from the experimental plots outside before they had bloomed, were inoculated. *Poa pratensis*, *Dactylis glomerata* and *Alopecurus pratensis*, which are all hosts of the ergot of rye. On June 8, rye growing out in the open, and on June 10 and 11 *Arrhenatherum elatius* and more rye in the greenhouse, also brought in from outside, were inoculated with the spore-containing solution of the sclerotia of September 1913, but without any positive result.

On June 12, thirty-five stalks of rye in bloom were inoculated with old conidia—with negative results.

July 3, three more stalks of rye then in bloom were treated with fresh conidia, but without any appearance of honeydew.

A number of oats in flower, also specimens of *Elymus dasystachys* and *Agropyron tenerum* were inoculated repeatedly with old and fresh conidia without any positive result.

It may be said that the study of this form of ergot proved most interesting. The rapidity of the development of stromata and the large number observed make this ergot a most desirable one for class purposes. From certain morphological differences, the difference in the measurements of conidia and ascospores, the fact that plants readily infected with spores of *S. clavus* (D. C.) Fries, proved immune in my experiments, and from some other biological features, I feel justified in considering this ergot a distinct species, and in proposing for it a new specific name. On completion of my work, the usual diagnosis will accompany the final account.

In conclusion, I wish to acknowledge my indebtedness to H. T. Güssow, the Dominion Botanist, for his kindness in editing the manuscript and making timely and important suggestions.

DIVISION OF BOTANY

EXPERIMENTAL FARM

OTTAWA, CANADA

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EXPLANATION OF PLATE XI

Artificially infected flowers of wild rice.
Various stages of germinating ergots.



Photo. A. E. Kellett.

FYLES: A PRELIMINARY STUDY OF ERGOT OF WILD RICE

A POWDERY MILDEW ON CITRUS

C. N. C A R T E R

WITH PLATE XII AND ONE FIGURE IN THE TEXT

In May 1911 a fungus was found by the writer upon a Dancy tangerine tree (*Citrus nobilis*, Lour. var.) in an orange grove at Duarte, Los Angeles County, in the southern part of California. The fungus appeared to be a powdery mildew and specimens were sent to Prof. W. T. Horne of the University of California, at Berkeley, for examination. The writer was advised that the fungus was undoubtedly a powdery mildew and was worthy of further study. In the same year inoculations were made upon roses and citrus trees other than tangerines near the original infestation. Conidia from tangerine leaves were placed on rose leaves and conidia from the rose leaves were placed on marked leaves of the tangerine, but in all cases results were negative. A covering was placed over the leaves in every case.

In 1912 the mildew was first observed in June, and the writer began to search the immediate neighborhood and nearby districts for its further occurrence. It was found on a tree of Dancy tangerine growing alone about two miles from the point of original observation. A grove of large and particularly good tangerine trees near Azusa was examined and the mildew found rather abundantly. While not enough to appreciably affect the vigor of the trees, it immediately suggested the possibility of more serious development such as has occurred with the powdery mildew of apples in some parts of California.

The leaves are the only parts of the tree affected. The young, tender growth with leaves about two thirds developed is most susceptible. The first appearance of the fungus on the young leaf occurs on the edge, usually as isolated spots 2 to 5 mm. broad. The hyphae of the mycelium can be plainly distinguished as very fine radiating lines. There is a darkening and usually a perceptible depression of the invaded leaf surface, followed by a general buckling of the whole leaf. The crumpling increases and new infection may take place along the center, but always on the upper surface of the leaf. On closer observation it will be found that the coloring matter has disappeared and in the older stages the spots become decidedly yellow. The old affected leaves which remain on the tree have a more or less characteristic appearance. The edges turn down very sharply, especially where the infection has taken place on the edges of the leaves.

A favorable place for older infections of the mildew seems to be along the midrib. The greatest number of affected leaves are to be found on the north and west sides of the tree, towards the center and near the ground. In the center of the tree, where it is more or less shady, all stages of the mildew may be found. Very seldom do affected leaves occur near the top of the tree.

It is evident that mist and fog favor the spread and growth of the fungus. Apparently the most favorable conditions are furnished by decidedly damp mornings when the sun does not come out until midday. Although the past spring was exceptionally cool and cloudy, the mildew fungus did not grow so vigorously as in the previous seasons when there were more moist foggy mornings.

The mycelium may be readily seen spreading out on the leaf as superficial, white threads, radiating more or less and sparse at first. In subsequent stages the mycelium becomes denser but never felty. The patches spread out and finally become confluent, especially along the midrib of the leaf. The conidiospores are visible to the naked eye, standing up from the leaf. It would appear that the mycelium which is barren late in the season remains dormant on the green leaves through the winter and when favorable conditions return produces conidia to infect the younger leaves in the spring. No perithecia have been observed.

The mildew on *Citrus nobilis* presents the microscopic characters shown in figure 1.

The mycelium measures 4.5 to 6.7 μ in diameter. The conidiophores are 60 to 120 μ long and about 12 μ broad at the top, becoming slightly narrower below. The conidia are borne in chains of four to eight. In making measurements of twenty or more conidia from dried specimens, considerable variation in size was noted. They are usually barrel-shaped with flattened or slightly rounded ends and measure 20 to 28 μ by 10 to 15 μ . The appresoria are roundish and are 10 to 12 μ in diameter.

In order to find out whether such an Oidium has been reported on *Citrus nobilis*, W. T. Horne, of the University of California requested

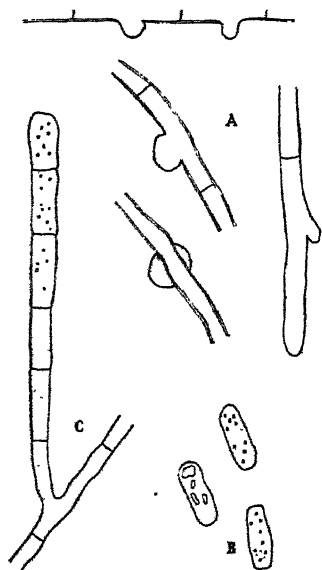


FIG. 1. a, Appresoria on hyphae of the mycelium; b, a group of three conidia drawn from dried material; c, conidiophore with chain of conidia. All magnified 333.3 diameters.

Mrs. Flora W. Patterson of the Bureau of Plant Industry, United States Department of Agriculture, Washington, D. C., to have search made of the mycological literature. The work was carried out by Mr. F. J. Veihmeyer and no *Oidium* was found which corresponds in any way with the one under discussion.

"*Oospora citri-aurantii* (Ferr.) Sacc. et Sydow, *Oidium Citri-aurantii* Ferraris, *Malpighia* XIII, p. 12, has been reported as occurring upon putrefying fruit of *Citrus aurantium* in Italy."

"*Acrosporium fasciculata*, Greville's *Flora Edinensis*, is reported on decaying oranges. This is presumably the same fungus as *Oidium fasciculatum* Berk. and *Oospora fasciculata* (Berk.) Sacc. and Vogl."

These are the only two cases of *Oidium* reported from the thorough search made, and in both cases it occurred on decaying fruit and therefore is not to be confused with the fungus under consideration.

Accordingly the name *Oidium tingitaninum* is proposed for it in reference to its particular host, the tangerine, and the following technical diagnosis, based on a study of both living and dried specimens is given.

***Oidium tingitaninum* sp. nov.**

Patches developing on immature leaves, epiphyllous near the margins and along the center becoming more or less confluent and sometimes covering most of the leaf, whitish, sparsely powdery, the leaf surface below the mycelium early becoming stained brown, darkening with age and finally losing part of its green color. Mycelium not dense nor felty, mostly disappearing with age; hyphae 4.5 to 6.7 μ in diameter. Appressoria rounded; conidiophores 60 to 120 by 12 μ ; conidia in chains of four to eight, colorless, finely granular, barrel-shaped with slightly rounded ends, variable in size 20 to 28 by 10 to 15 μ .

Habitat: On leaves of Dancy tangerine, *Citrus nobilis* Lour, var. Los Angeles County, California. Type material has been deposited in the Herbarium of the University of California, at Washington, D. C. and in the New York Botanical Gardens.

Latin diagnosis. O. maculis in foliis nondum maturis orientibus, epiphyllis, atque margines et aream centralem foliorum occupantibus, deinde plus minusve confluentibus nunc maximam superficiem foliorum vestientibus, albidis, sparse pulverulentis, superficie foliorum sub maculis fere ab initio fuscetecolorata sed aetate provecta fuscior et ultime partem coloris viridis amittente; mycelio neque denso neque dense lanoso intertexto, aetate provecta maxime evanescenti; hyphis 4.5-6.7 μ in diametro; appressoriis rotundatis; conidiophoris 60-120 x 12 μ ; conidiis 4-8 catenatis, hyalinis, minute granulatis, doliiformibus, apicibus parve rotundatis, in magnitudine variabilibus, 20-28 x 10-15 μ .

SUMMARY

A powdery mildew disease due to a species of *Oidium* has been observed on the leaves of the Dancy tangerine, *Citrus nobilis* Lour. var. This is believed to be the first report of a disease of this type on plants of the genus *Citrus*.

The fungus concerned has been found only in a limited area in southern California. It appears to be restricted to one variety of tangerine orange and to depend on the occurrence of warm weather, wet fog, and abundant new growth at the same time. It has been under observation for four seasons and there is no reason to fear that it will have any economic importance in California.

The name *Oidium tingitaninum* is suggested for this fungus and a technical diagnosis is presented.

A number of inoculations have been made but these have not succeeded on tangerine or any other plants. *Oidiums* from other plants have failed to grow on tangerine.

From observations made in the field during more than three years, the fungus reappears about the month of May, but there is considerable variation from year to year as to its abundance.

I am under obligations to Prof. W. T. Horne for his special interest and attention in this work. Professor Setchell very kindly prepared the Latin diagnosis and gave suggestions as to the proper name. I am indebted to Mr. C. O. Smith for his interest in the work and to the Slauson Ranch, Azusa, for material. Mr. R. M. Teague of the San Dimas Citrus Nurseries very kindly supplied budded citrus stock for inoculation work.

COLLEGE OF AGRICULTURE

UNIVERSITY OF CALIFORNIA

BERKELEY, CALIF.

EXPLANATION OF PLATE XII

FIG. 1. Tangerine leaf shortly after reaching full size and yet not fully mature. The most conspicuous spots of *Oidium* show on the midrib.

FIG. 2. Leaf at very nearly the same stage as in figure 1. Spots here are more strongly developed toward the margin.

FIG. 3. Six tangerine leaves at full maturity showing the characteristic buckling due to powdery mildew. The mycelium was still evident on these leaves but was beginning to disappear. All nearly natural size.



CARTER: POWDERY MILDEW ON CITRUS

PHYTOPATHOLOGICAL NOTES

A new scarlet oak disease. A new fungus belonging to the genus *Botryodiplodia* has been found to be causing a serious killing of the young branches on scarlet oak in the vicinity of Cincinnati. About 150 to 200 scarlet oaks, *Quercus coccinea*, are affected at the Spring Grove cemetery. Further investigations will be carried on this coming summer and complete results published in the near future. Material of similar oak diseases will be appreciated.

D. C. BABCOCK

OHIO AGRICULTURAL EXPERIMENT STATION

Lightning injury to onions. Since reading the article in a recent issue of PHYTOPATHOLOGY on Lightning Injury to Potato and Cotton Plants by Jones and Gilbert, the writer thinks it of sufficient interest to make note of a case of lightning injury which came to his attention in an onion field at Marion, New York, in the summer of 1914. In this case the injury to the onion plants, which were about one foot high, was noticed shortly after a severe electrical storm, and it was observed by workmen that the lightning struck in the locality where injury was later discovered. The field was visited by the writer some days later when it was found that the plants were killed over an area of about eight feet in diameter, while plants immediately adjoining this area showed injury. The muck soil in the center of the lightning-struck spot was disturbed or thrown out to a depth of approximately four inches and over an area of a few inches.

M. T. MUNN

Correction. In the April number of PHYTOPATHOLOGY (p. 97), in connection with the discussion of lightning injury to potatoes, I cite Prof. F. C. Stewart as authorizing the statement that he attributed to lightning an injury observed in New York potato fields. This is incorrect. My statement was based upon what proves to be a misinterpretation of Professor Stewart's joking reference to the "lightning bug" in a letter he wrote me after reading the abstract of the same paper in the program of the Philadelphia meeting. The joke was really a good one, but, as with some of my earlier experiences with lightning flashes, I was not quick enough to interpret it correctly. The facts are, as Professor Stewart intended me to understand from the first letter and now authorizes me to state on his behalf, that he considers the evidence to justify the conclusion that the "lightning bug" responsible for the damage in the New York potato fields referred to is the stalk borer, *Papaipema nitela* Guen. While he did not

find the insects he did find evidence of the larval invasion in every dead plant examined.

It is noteworthy that the general appearances of the dead spots in the potato fields were so similar in the two cases and this emphasizes the need of attention that the two types of injury be not confused.

L. R. JONES

Personals. Dr. F. Kølpin Ravn, Professor of Plant Pathology at the Royal Landbohøjskolen, Copenhagen, Denmark, will come to this country during the first week in May and engage in a series of conferences with officials of the United States Department of Agriculture and of state experiment stations in the various states, on problems concerned with cereal cultivation, particularly cereal diseases. It will be remembered that Doctor Ravn has published particularly valuable papers on the leaf diseases of barley.

Dr. J. Rosenbaum, until recently Instructor in Physiology in Cornell University, has been appointed to a position as Assistant Pathologist in Truck Crop Disease Investigations, Bureau of Plant Industry, United States Department of Agriculture, to take up work on potato diseases.

Dr. F. L. Stevens has prepared a preliminary draft of a Bibliographic Appendix to his book *The Fungi which Cause Plant Diseases*, consisting of 32 typewritten pages of additional references to literature. Copies may be secured from Dr. Stevens at Urbana, Illinois, for 50 cents each.

A short course on the diseases of plants as related to their keeping quality during transportation and storage was given by the University of Illinois, February 8 to 20, by Dr. F. L. Stevens and Mr. Geo. L. Peltier.

Mr. Ernest E. Hubert, a graduate of the University of Montana, and former employee of the Forest Service of the Department of Agriculture, has been appointed to a temporary position as Field Assistant in Forest Pathology in that Department and stationed at Missoula, Montana, where he will work under the direction of Dr. Jas. R. Weir during the period from January 1 to July 1.

The death is reported of Mr. Y. Takahashi, Pathologist of the Hokkaido Agricultural Experiment Station, Japan, on November 14, 1914. The position has been filled by the appointment of Mr. Leiya Ito, Assistant Professor at the Tohoku Imperial University, and Pathologist of the Experiment Station at Sapporo, Japan.

Publications of the Insecticide and Fungicide Board. The attention of pathologists is called to the publications issued by the Federal Insecticide and Fungicide Board of the United States Department of Agriculture, portions of which may be of interest. The Service and Regulatory Announcements, eight numbers of which have been issued, the first dated March 16, 1914, and the last April 3, 1915, contain extracts from various letters written by the Board to manufacturers of insecticides and fungi-

cides, expressing opinions of the Board with reference to the labeling of insecticides and fungicides in accordance with the Insecticide Act of 1910. These announcements are prepared primarily for and distributed among manufacturers, the object being to more fully acquaint them with the views of the Board in regard to the manner in which various types of insecticides and fungicides should be labeled, and thereby enable them to avoid errors, which they would be likely to make if such information were not available. For example, in S.R.A. No. 1, pages 6 and 7, are found extracts from letters written to certain manufacturers concerning faulty recommendations on the labels of Bordeaux mixtures, which contain the opinion of the Board in regard to certain statements representing very common types of errors. This publication also contains the notices of judgment of cases under the National Insecticide Act which have been settled in court, some of which may be of interest to plant pathologists. The Insecticide Decisions, six of which have been issued, the first August 26, 1911, and the last February 12, 1912, represent another form of attempt by the Board to enable manufacturers to label their products in accordance with the Act. Insecticide Decision No. 6, relative to inert and active ingredients of Bordeaux mixture, is of this nature.

M. B. WAITE

ERRETT WALLACE

Desiderata. Announcements will be inserted in the Phytopathological Notes section of this JOURNAL, concerning the wants of members of the Society in the way of cultures, specimens, or exchanges.

San Francisco Meeting of the American Phytopathological Society. The Society at its Philadelphia meeting decided to hold a special meeting at San Francisco, August 2-7, in connection with the meeting of the American Association for the Advancement of Science.

It is hoped that there will be as good an attendance as possible. All members planning to visit the Pacific Coast or the Exposition should arrange to do so at the time of this meeting. An interesting program is expected. Special attention will be given to Pacific Coast problems.

C. L. SHEAR, *Secretary-Treasurer*

The Western American Phytopathological Society. A meeting of the Western American Phytopathological Society was held at Corvallis, Oregon, on December 29 and 30, 1914. The first meeting was held on the afternoon of December 29 and was given over to discussion of topics of special interest to members present. Considerable part of the afternoon was spent in the discussion of pear blight in the Pacific Coast region. The visiting members were entertained at a banquet in the evening and on the following day three sessions were held at which the following program was presented:

Investigation of physiological plant diseases.....R. E. SMITH
Wilt disease of carnations.....C. J. WIGHT

<i>Sappy bark disease of apples and Polystictus versicolor</i> , Wm. T. HORNE and C. J. RODGERS	
<i>Melazuma of walnuts</i>	H. S. FAWCETT
<i>Preliminary studies of resistance of Prunus to inoculation with Bacterium tumefaciens</i>	C. O. SMITH
<i>A new filbert disease in Oregon</i>	H. P. BARSS
<i>Notes, observations and investigations of plant diseases in Western Oregon</i>	H. L. REES
<i>Inoculation studies with apple tree anthracnose</i>	H. S. JACKSON
<i>Minor notes on interesting diseases</i>	H. S. JACKSON
<i>Warnock's tree paint as a cure for fire blight</i>	J. W. HOTSON
<i>Internal brown streak of potato</i>	S. S. ROGERS
<i>Cottony rot of lemon (Sclerotinia libertiana)</i>	C. O. SMITH
<i>The prevention of wood decay in trees</i>	Wm. T. HORNE
<i>Apple scab, spraying experiments in the Hood River valley</i>	J. R. WINSTON

A telegram of greetings was sent to the parent society which was in session at the same time in Philadelphia.

The society voted to hold the next meeting at San Francisco and the executive committee was instructed to arrange for a joint meeting with the parent society.

About twenty-five persons attended the meeting, including representatives from Oregon, Washington, California and British Columbia.

WM. T. HORNE, *Secretary-Treasurer*

Charles Edwin Bessey. It is with the deepest regret that we announce the death of Prof. Charles E. Bessey, the distinguished botanist and teacher, and a beloved charter member of The American Phytopathological Society. Dr. Bessey died at his home in Lincoln, Nebraska, February 25, in the seventieth year of his age, having been born May 21, 1845. He was Professor of Botany in the University of Nebraska for thirty-one years. He leaves a wife and two sons, Carl and Ernst.

A brief biographical sketch of Professor Bessey prepared by the writer will be found in the Asa Gray Bulletin, Volume 4, page 23, March, 1896.

Though not a specialist in Plant Pathology, Professor Bessey took an active interest in the subject and was ready and willing at all times to do what he could to promote its interests and those of our Society. Only a short time before he was taken sick he expressed to the writer his belief that we should be able to secure an endowment for PHYTOPATHOLOGY, and also his determination to render all the assistance he could to accomplish this purpose. The loss to botany caused by Dr. Bessey's death will be deeply felt by his fellow botanists. How great this loss is, not only to science but to humanity, can only be understood by those who had the good fortune to sit at his feet as students or have enjoyed association with him as a friend and co-worker. His "boys and girls," as he affectionately termed his students who specialized in botany, will feel that they have lost not only a noble and devoted teacher, but also a beloved friend and adviser.

C. L. SHEAR

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¹ This list aims to include the publications of North and South America, the West India Islands, and islands controlled by the United States, and articles by American writers appearing in foreign journals.

All authors are urged to cooperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agric., Washington, D. C.

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PHYTOPATHOLOGY

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ROOT ROT OF CONIFEROUS SEEDLINGS

ARTHUR H. GRAVES

WITH TWO FIGURES IN THE TEXT

Authenticated cases of death of trees from root rot caused by lack of oxygen in the soil, i.e., from asphyxiation, are not common. Hartig¹ has described an example of such a condition occurring in young thirty-years-old Scotch pines in Germany, where, according to him, circulation of air in the soil became more and more restricted due to conditions incident to forest growth, resulting eventually in the practical exclusion of air from an argillaceous substratum.

The writer has seen cases of large tulip trees, *Liriodendron tulipifera* L., dead from this cause near Lakes Toxaway and Fairfield, North Carolina. Both of these lakes are of quite recent artificial origin, and it is probable that by their formation the water table in the immediate vicinity was so raised that the roots of the tulips in question were drowned out.

The suffocating effect of piling large quantities of earth upon the roots of trees during building or road cutting operations is becoming better understood in this country, as evidenced by the increasing number of cases where "wells" are built around such trees in order to provide for the maintenance of an air communication with the roots.

In the diagnosis of tree diseases, one is often tempted, when a visible cause is not apparent, to locate the seat of the trouble in the roots. But in large trees an examination of the roots for direct evidence is usually difficult. With young seedlings, however, the case is different, and on this account the trouble about to be described in this paper deserves notice.

The disease in question appeared in the nursery of the Yale Forest School during the spring and early summer of 1914, and was particularly

¹ Hartig, Robert. Text-book of the diseases of trees, pp. 276-278. English Ed. 1894.

destructive. Besides the loss of about twenty per cent of a bed of one-year-old red pines, *Pinus resinosa* Ait., and five per cent of a bed of one-year-old white pines, *Pinus strobus* L., several thousand two-years-old red pines succumbed, as well as a few seedlings of one-year-old hemlock, *Tsuga canadensis* (L.) Carr.

The disease first became noticeable through a dark red or reddish brown coloration of the tips of the leaves. In the initial stages the contrast of this dark red color with the remaining deep green of the leaves was very striking. By slow degrees, extending over an interval of several weeks, the red color extended throughout the entire leaf to its base. Subsequently the reddish hues changed usually to browns, or yellow-browns, and the final color was, in most cases, some shade of yellow, although often intermixed with reddish tints.

A long period—at least a month—was required for this sequence of color changes; and, at the end of this time, in case the disease had proved fatal, the whole plant was stiff, dry, and entirely dead.

When the disease was first critically examined, early in May, it was suspected that the leaves had sustained a fungous trouble of the nature of the well known *Schüttekrankheit*, both because of their discoloration as well as from the fact that the diseased plants appeared to be located in more or less irregular patches scattered throughout the beds. However, examinations of the discolored leaves, even on plants where the disease had progressed far, failed to disclose any fruiting bodies or mycelium of a fungus, nor did incubation succeed in bringing to light any pathogenic form.

It was evident that the patches of diseased seedlings were almost always situated in slightly sunken portions of the beds, as well as along their margin, where drainage was poorest.

Diseased seedlings which had been carefully uprooted revealed a root system that was almost without exception entirely dead. This was the case even when the leaf discoloration had not yet started in, the only evidence of trouble being in the failure of the terminal bud to unfold and develop the leaves of the year (fig. 2). These conditions, joined to the fact that where the discoloration had appeared it uniformly commenced at the *tips* of the leaves, clearly indicated a root trouble of some sort.

That this root trouble was not of fungous origin, but was due primarily to unfavorable soil conditions, was borne out by the following considerations:

1. Repeated attempts to isolate from the roots a pathogenic fungus or fungi as causal organisms in the disease were always attended with negative results. These experiments consisted of (1) incubation in moist

chambers, of roots which had recently died, (2) insertion of the inner portions of diseased roots, removed with a sterile scalpel, in nutrient agar, and (3) placing such roots, whole, in nutrient agar. In every case no forms appeared except saprophytic fungi, and bacteria which were presumably saprophytic. One fungus, which was kindly identified by Mrs. Flora W. Patterson, *Cylindrocladium scoparium* Morgan,² was of



FIG. 1. One-year-old seedlings of *Pinus resinosa*, showing recovery from root rot. A new, healthy, whitish root shows in each case. Shoots commencing a belated growth. In the figure to the right the new root has just started from the base of the stem.

such general occurrence that it was viewed with suspicion, but inoculations of healthy seedlings in sterilized soil with this form gave only negative results.

2. The soil of the seed beds was stiff and clayey, and although a considerable amount of leaf mould had been added to it, there was still a

² Morgan, A. P. Two new genera of Hyphomycetes. Bot. Gaz. 17: 190-192. 1892.

very small proportion of humus. As a consequence its porosity was slight, and in rainy periods the water would stand for some time in the hollows and poorly drained parts. Such conditions would naturally prevent a free access of oxygen to the roots, and would therefore readily promote root rot.

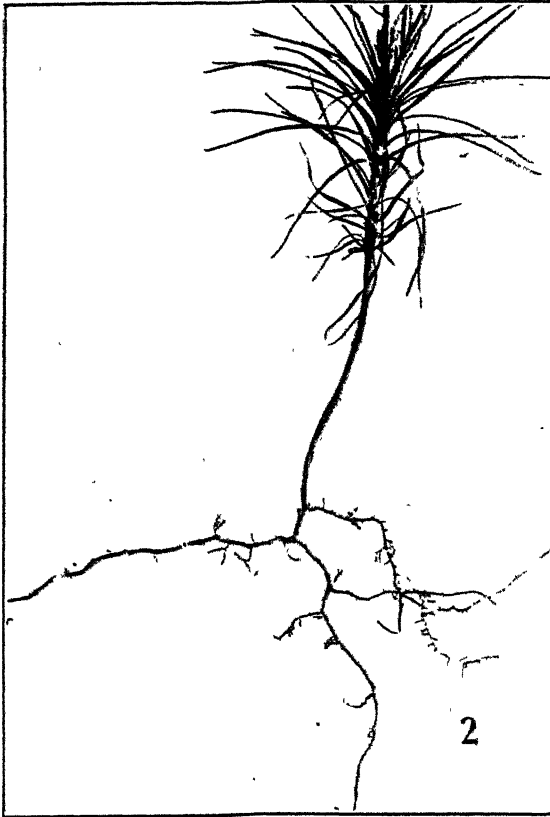


FIG. 2. Seedling of *Pinus resinosa*. Roots entirely black and dead. Top still alive, but no growth evident.

3. The disease caused most havoc during the months of March and April, when the soil was still soggy from the winter freeze and rains, and when the roots, on the other hand, stood in the greatest need of oxygen for the commencement of metabolic activities incident to the season's growth.

4. In June and July, when the soil conditions were much improved over those of early spring, many cases of recovery from the disease were observed, as shown by the fact that new roots had developed in the region

of the root collar (fig. 1). At this time seedlings which were recovering and forming new roots could be detected very often by a glance at the tops. If these were starting a belated growth, inspection of the root system in every case would reveal usually one or sometimes more new roots, conspicuous by reason of their white color, their thickness, and origin high up, near the base of the stem (fig. 1). Such recovery, which was of fairly common occurrence, is more in line with a physiological trouble, than a disease caused by a parasitic fungus.

5. The course of the disease was slow, requiring at least a month for its completion. In many cases, even after three months of growth, i.e., about August, the tops still appeared healthy, although the year's growth had not developed, and examination of the roots showed them to be apparently dead. Here a considerably longer period would have been necessary before the plants entirely succumbed. A very gradual death of this sort would not be expected if the trouble were due to the attack of a parasitic fungus.

6. In soil of a similar character, in another part of the nursery, which had been thoroughly limed, and contained a generous amount of humus, such a disease had never been known to occur. This soil was loose and porous, never retaining water on its surface for any length of time.

The conclusion is therefore that the disease was due to lack of oxygen trouble in a soil which was saturated with water; i. e., that the roots were suffocated.

As already intimated, the remedy would consist in a thorough liming of the soil. Probably this in itself would be sufficient, but the addition of more humus would also improve the physical character of the soil as well as benefit the plant growth directly.

NEW HAVEN

CONNECTICUT

TELIAL STAGE OF GYMNOSPORANGIUM TUBULATUM ON JUNIPERUS SCOPULORUM

JAMES R. WEIR

The original collection of the aecial stage (*Roestelia tubulata* Kern) of *Gymnosporangium tubulatum* Kern was made by Marcus E. Jones¹ on *Crataegus douglasii* Lindley near Flathead Lake in Montana. Apparently no clue to the telial stage was found at the time, neither has it been experimentally determined since that date.

In the vicinity of Missoula, Montana, the aecial stage of this Gymnosporangium, as determined from material sent to Dr. F. D. Kern, for the past few seasons, has been so very abundant on *Crataegus douglasii* that it annually causes a premature falling of the leaves of its host. It was observed that the worst cases of defoliation were in close proximity to juniper trees of the species *Juniperus scopulorum* Sargent, whose branches and twigs were thickly covered with irregularly lobed telial galls. This seemed to indicate that this juniper is the alternate host of the fungus, a suspicion which has been experimentally proved by the following method. In early spring before the leaves of the haw appeared, a glass tube two feet long and two inches in diameter was placed on a section of a branch of a tree in a part of the Missoula valley where the rust does not occur and firmly tied in position. The ends of the tube were thoroughly plugged with surgeon's absorbent cotton and protected from the direct rays of the sun. As soon as the leaves were sufficiently unfolded inside the tube, one of the plugs was removed, the leaves were thoroughly sprayed with water containing germinating teliospores from the galls on the juniper, and the plug was replaced. The teliospores were taken from galls which had gelatinized in the laboratory. After nine days the leaves bore the pycnial stage, and before two months had elapsed the aecial stage appeared in such abundance that the leaves became very much deformed. Only the leaves covered by the tube were infected. This proves beyond doubt that *Juniperus scopulorum* bears the telial stage of *Gymnosporangium tubulatum*. The aecial form is chiefly foliicolous although the fruit of the host is often seriously infected.

INVESTIGATION IN FOREST PATHOLOGY

BUREAU OF PLANT INDUSTRY

MISSOULA, MONTANA

¹ Montana Botany Notes. University of Montana Bul. 61: 64, 1910.

THE AFTER EFFECT OF SULFUR TREATMENT ON SOIL

C. D. SHERBAKOFF

WITH THREE FIGURES IN THE TEXT

The after effects of sulfur treatment on soil for the control of potato scab has received brief consideration by various investigators. Halsted¹ found that an application of 720 pounds of sulfur per acre reduced the succeeding crop of potatoes nearly half. Wheeler, Hartwell and Moore² found a marked reduction in the yield of two cereals, oats and millet. Their experiments were performed in large size pots, not in the field. Demolon³ reports that a dosage of 80 grams (kilograms ?) of sulfur per hectare had an injurious effect on cereals when used on a soil poor in calcium. He attributes the injury to too strong acidification of the soil.

The writer⁴ has reported on an extensive field experiment in which on two succeeding years, areas of considerable extent were divided into test plats and treated with sulfur in varying combinations and quantities. Briefly stated the plan of the experiment is as follows:

A field was divided into equal parts and each part again divided into plats measuring 182.5 feet by 12 feet. Potatoes were grown on both parts in 1912 and in 1913. One part was treated in 1912, the other was treated in 1913. The experiment was performed in replication and was abundantly checked by untreated plats. The special treatments of the plats were as follows: (1) Sulfur alone, applied at the rate of 450 pounds and of 900 pounds per acre; (2) Sulfur at the rate of 450 pounds and of 900 pounds per acre in combination with lime at the rate of 350 to 400 pounds per acre and with commercial fertilizer (potash, 10 per cent, phosphoric acid, 8 per cent) 900 to 1000 pounds per acre; (3) the above amounts of lime and of commercial fertilizer per acre without sulfur.

In 1914 the field was sown to clover by the owner the seed being distributed broadcast. A marked difference was noted in the uniformity

¹ Halstead, B. D. Experiments with potatoes. New Jersey Agr. Exp. Sta. Rept. 18: 276-284. 1898.

² Wheeler, H. J., Hartwell, B. L., and Moore, N. L. C. Upon the after effect of sulfur, when applied to soils for the purpose of preventing potato-scab. Rhode Island Agr. Exp. Sta. Rept. 12: 163-167. 1899.

³ Demolon, A. Recherches sur l'action fertilisante du soufre. Compt. Rend. Acad. Sci. Paris 156: 725-728. 1913.

⁴ Sherbakoff, C. D. Potato scab and sulfur disinfection. New York (Cornell) Agr. Exp. Sta. Bul. 350: 719-740. 1914.

of stand in the field. Certain narrow areas were practically bare and other areas produced a very poor stand. The field was left in clover and on June 1, 1915, the writer had an opportunity to examine it with the following results:

1. Wherever sulfur was used at the rate of 900 pounds per acre, whether the application was made in 1912 or in 1913, and whether the sulfur was used alone or in combination with lime or commercial fertilizer, there was a noticeably poorer stand of clover than on adjacent plats or there was no clover at all (fig. 1). The injurious effect of sulfur was most noticeable on that part of the field which was somewhat gravelly and



FIG. 1. In the centre of the figure is a plat treated in 1913 with sulfur at the rate of 900 pounds per acre. The plat on the left was treated with sulfur at the rate of 450 pounds per acre and the plat on the right received no treatment. The stand of clover varies markedly on the differently treated plats. Field sown to clover in spring of 1914, photograph made June 1, 1915.

relatively poor in humus. In one corner of the field where the soil is a good loam, rich in humus, there was practically no injury.

2. The plats treated with sulfur at the rate of 900 pounds per acre in combination with lime and with commercial fertilizer showed less of the injurious effects than where sulfur in this amount was used alone (fig. 2).

3. When sulfur was applied at a somewhat greater ratio than 900 pounds per acre, as was the case at the ends of the plats where the sulfur drill was turned, there was often no plant growth at all (fig. 3).

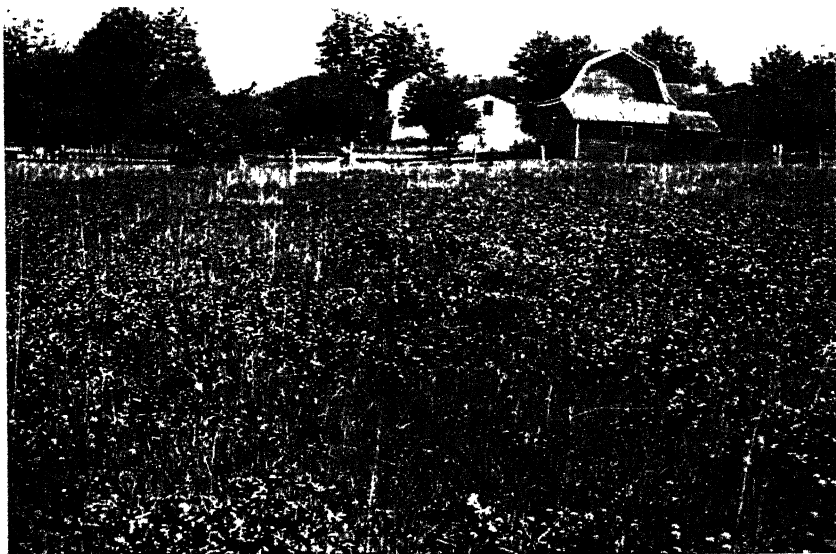


FIG. 2. In the centre of the figure is a plat treated in 1912 with sulfur at the rate of 900 pounds per acre and lime at the rate of 350 pounds per acre. The plat on the left was treated with lime alone at the rate of 350 pounds per acre and the plat on the right received no treatment. The contrast is not so marked as in figure 1, apparently on account of the lime used in combination with the sulfur. Field sown to clover in spring of 1914, photograph made June 1, 1915.

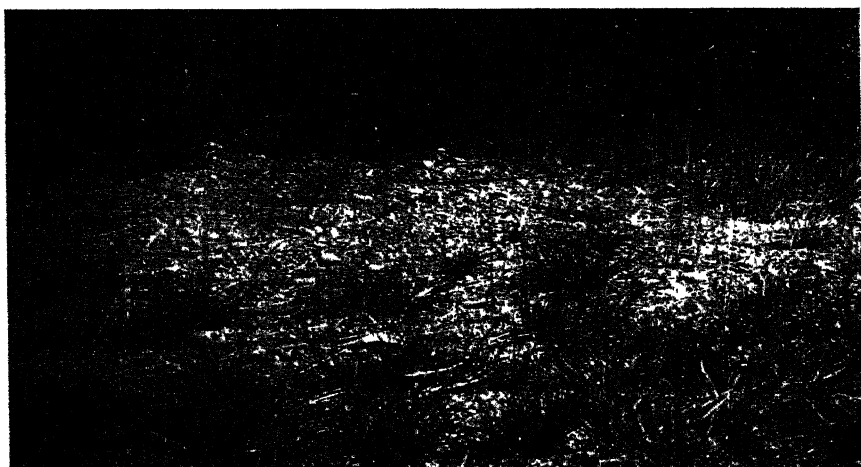


FIG. 3. An entirely sterile area in the clover field. This area lies just outside a plat treated in 1912 with 900 pounds of sulfur per acre and is the point where the sulfur drill was turned. The machine made a slow turn thus distributing an excess of sulfur.

4. The treatment with sulfur at the rate of 450 pounds per acre either alone or in combination, showed an injurious effect only in those parts of the field poor in humus and in no case was it as marked as where the larger quantity of sulfur had been used.

These observations are in accord with observations of a less extensive nature made in the spring of 1913. The entire field was seeded to a winter cover crop of rye in the autumn of 1912. The following spring there was a noticeable difference in the stand of rye on the variously treated plats.

AGRICULTURAL EXPERIMENT STATION

GAINESVILLE, FLORIDA

PERIDERMIIUM PYRIFORME AND CRONARTIUM COMANDRAE

J. E. KIRKWOOD

Several contributions of late years on the subject of the Peridermiums have left unsettled the exact relationship existing between some of the well known species and their alternate hosts. Arthur and Kern,¹ in discussing the North American Species of Peridermium, make no mention of the alternate phase of *Peridermium pyriforme* beyond referring all Peridermiums upon pines to the genera *Coleosporium* and *Cronartium* for the telial condition. Arthur² in his treatment of the Uredinales in the North American Flora, states that the aecial condition of *Cronartium Comandrae* is unknown. In a recent paper, however, Arthur and Kern³ have reached the inference that *Peridermium pyriforme* is the alternate phase of *Cronartium Comandrae*, basing their conclusion upon the co-extensive distribution of the two supposedly distinct species of rust, and the fact that the species of *Cronartium* in question seemed to be the only unattached form. And finally the author is informed, though he has not had the pleasure of seeing the article, that Hedgecock and Long, in a privately printed paper, have recently published the results of observations whereby they are led to believe that *Cronartium Comandrae* is but the alternate phase of *Peridermium pyriforme*.

In May, 1912, a student brought to the botanical laboratory of the University of Montana, a piece of the stem of a young pine, apparently *Pinus ponderosa*, which bore, on a slightly swollen part, irregular, sinuous ruptures of the bark filled with the orange colored spores of *Peridermium pyriforme*. Inoculations with these spores were made immediately upon Comandra plants of the species *pallida* growing on a hillside near the University campus. Absence of the author from town for the whole of that summer involved the neglect of the plants so treated until his return in the fall, when the plants were found heavily infected with *Cronartium Comandrae* in the telial condition. However, as other plants for a distance of 100 feet around were likewise beset with the parasite,

¹ Arthur, J. C. and Kern, F. D. North American Species of Peridermium. Bul. Tor. Bot. Club **33**: 403-436. August, 1906.

² Arthur, J. C. Uredinales. North American Flora **7**: 83-160. March, 1907.

³ Arthur, J. C. and Kern, F. D. North American Species of Peridermium on Pine. Mycologia **6**: 104-138. May, 1914.

misgivings were entertained as to the significance of the facts observed. At this time, early in October, telial columns of the *Cronartium* were used in an attempt to inoculate young trees of *Pinus ponderosa* growing in the nursery on the campus. Up to this date no apparent results have followed from this treatment, but this probably is due to the lateness of the season when the transfer was made.

Field observations supported the suspicion that *Pinus ponderosa* and *Comandra pallida* were the alternate hosts of the same fungus, for in the neighborhood of pines bearing *Peridermium* galls the *Comandra*, when present, is badly diseased with *Cronartium*, and the two host plants are very often and commonly associated.

Subsequent inoculations of the yellow pine made by the author at different times were not successful until last season, when in July, 1914, fresh spores from *Comandra* were inserted in incisions in the bark of the young pines. Sections prepared from some of the pine twigs at the points of inoculation now show distinct development of the hyphae in the wound; they ramify through the resin ducts and the intercellular spaces of the cortex, traversing the medullary rays to the cells of the pith, and extend up and down through the tracheids. Where the rays are occupied by the hyphae they become discolored, assuming a brown tinge. Comparing these sections with others made from twigs of pine known to be infected with the *Peridermium* reveals a condition similar in essential respects, as far as the hyphae are concerned, to that above described. Some structural peculiarities of the parasite are noticeable as well as its behavior with reference to the tissues, albeit galls have not yet formed.

Mr. E. E. Hubert, cooperating with the writer, in May, 1914, transferred spores of *Peridermium pyriforme* to pulp of crushed *Comandra* leaves and observed the production of the germ tubes. He also inoculated field plants with the spores and later found these plants infected with *Cronartium Comandrae*.

The above results are not regarded as conclusive, but as strong evidence that *Peridermium pyriforme* and *Cronartium Comandrae* are but the alternate phases of the same rust. Moreover, so far as the writer is aware, no records are published of the successful transfer of the parasite from *Comandra* to the pine, other than the results submitted herewith. Further experimental work on this subject is in progress, the results of which will probably be presented soon with fuller data.

Appreciation of the kindness of Prof. J. C. Arthur in the identification of material is hereby gladly expressed.

UNIVERSITY OF MONTANA

MISSOULA, MONT.

METHODS OF INJECTING TREES

CAROLINE RUMBOLD¹

WITH PLATE XIII

Experimental work on tree injections was started in 1912 by the writer when working on the chestnut bark disease. The Pennsylvania Chestnut Tree Blight Commission was responsible for the beginning of the work and the University of Pennsylvania has cooperated by offering facilities for the laboratory work.

The first injections were made in the roots of the chestnut trees. This method has been suggested by E. S. Goff² in a report on the effect of artificial root pressure on trees. It was soon abandoned. The time spent in digging around the trees seeking roots adaptable for injection and the difficulties in making good injections in inconvenient positions overbalanced the possible advantages of the method.

Another method was tried, which was principally worked out by R. C. Walton, an assistant in the work. The method had been suggested to him by Chewyreuvs³ Extraradicate Nutrition of Diseased Trees. The method is a simple one, easily and quickly applied. A hole 2 inches by 1 inch was cut in the side near the bottom of a tin can, such as is used in canning vegetables. A lump of grafting wax of such consistency that it can be softened in one's hands was put on the trunk where the injection was to be made. The wax was pushed into the crevices of the bark and worked away from the center, until a space was cleared of the same size as the hole in the tin can. The can was then placed against the tree trunk so that the edge of the hole fitted the ridge of wax and the can was then bound in place with string (fig. 1). The object was to make a water-tight joint. The solution to be injected was poured into the can. The cut in the tree was then made by driving a quarter-inch chisel deep into the tree trunk, the chisel having been inserted from the top of the can through the hole cut in its side.

The disadvantages of this method are that the metal of the container

¹ Formerly Expert, Office of Investigations in Forest Pathology, Bureau of Plant Industry.

² Goff, E. S. Wisconsin Agr. Exp. Sta. Report 14: 272-282. 1897.

³ Chewyreuvs, Ivan. Extraradicate nutrition of diseased trees. Records of the Botanical Division. St. Petersburg Imperial Soc. of Naturalists. Conference of 1894.

reacts on the solutions and the grafting wax is likely to give way, allowing the solution to leak away. The interior of the tin can might be plated with an inert substance, or a glass container substituted. This latter device was tried. A hole was made in a Mason glass jar with hydrofluoric acid. The method of injection was the same as when the tin can was used except that the jar was placed on a small shelf fastened to the tree as well as tied against the trunk. The unreliability of grafting wax for making joints still remained a serious disadvantage, when the jars remained attached to the trees for several days.

Another method which does not depend on grafting wax for connections was devised by W. T. Bovie, an assistant in the work. This method is simple in design, easily applied, and does not need to be watched. A tin box was made which was 6 inches long, 4 inches deep, and 3.78 inches wide, open at the top and at one end (fig. 2, *a*). The box was placed with its open end in contact with the tree trunk and made fast by a copper wire wrapped around both the box and the trunk (fig. 2). Melted grafting wax was next applied to the edges of the box where it came in contact with the tree. If the wax is worked as it cools, a water-tight joint can be obtained easily. The tree trunk should be as free from wax as possible and yet the joint should be tight. The box was filled with water. This box is for the purpose of enabling one to cut a hole in the trunk without letting air enter the tissues of the tree. A glass (self-sealing) fruit jar (fig. 7, *b*) containing the solution to be injected was hung by a hook (fig. 7, *a*) in the tree above the point of injection. It was closed at the top by a cap of parchment paper (butter paper). A rubber tube (fig. 3, *a*; fig. 7, *c*) (glass tubes can be used if necessary), acting as a siphon, led the solution down to the point of injection. If rubber tubing is used, a short glass tube is inserted in the lower end of it. The other end of the glass tube joint passed through a perforated rubber stopper, 1 inch in diameter (fig. 3, *d*), the large end of the rubber stopper being turned toward the free end of the tube. An apparatus for holding the tube in place consisted of a block of wood 6 inches by 3 inches by 1 inch (fig. 3, *c*), in the center of which a hole was bored just large enough to take the small end of the rubber stopper. Two strips of hoop-iron (fig. 3, *e* and *e'*) were nailed to the ends of the board so as to extend at right angles from it; one of these strips (fig. 3, *e*) had two rows of holes punched into it, the other (fig. 3, *e'*) a series of teeth cut along each edge. These holes and teeth were to receive wires made out of spring brass (fig. 3, *g*). The wooden blocks, the metal strips, and the brass spring together made a clamp (figs. 3, 5, 6, and 7), which held the rubber cork pressed against the tree with a total pressure of over 40 pounds. The wire used in these clamps was No. 9. The details of this clamp will be understood by referring to figure 3, which is

a view looking down on a tree cut off at the point of injection. By having a number of holes and notches the clamps were adjustable to different sized trees. In a second series of clamps, larger than the first, there were blocks of wood which measured 9 inches by 3 inches by 1 inch and the strips of hoop iron nailed to the ends of the boards measured 9 inches also. The rubber tube must be passed through the hole in the clamp before the rubber stopper is put on. A clamp on the rubber tube will be found very convenient. It should be of the sort that can be removed after the connections are made.

One other device was helpful (necessary if working alone) in getting a water-tight connection. This was a piece of wood about 2 feet long fashioned into a handle, at one end of which a metal strip was fastened. This strip was at right angles to the wood and a notch was cut in the end which would just fit the rubber stopper at its middle (figs. 4 and 5). The wooden stick and metal together, wired to the tree, formed a bent lever and pressing down the handle with one's body forced the stopper against the tree (fig. 4). When all the apparatus was ready, the rubber tube was filled with solution and clamped off. A hole, varying in diameter according to need, was then cut with a one-fourth inch gouge into the tree under the surface of the water in the tin box. Care must be taken to have clean cuts at the top and bottom of this hole. The stopper was placed over the hole with the end of the glass tube entering it and held in place with the bent lever. The clamp was removed from the tube and the solution allowed to flow out around the stopper. When all the air bubbles were out of the tube, the flow was stopped by pressing down on the handle of the bent lever. The tin box was then removed and the clamp slipped around the tree (fig. 5). As soon as this was made fast, the bent lever was removed and the connections were then complete (figs. 6 and 7).

It is understood that the rubber stopper does not enter the hole in the tree; it is pressed against the outside of the tree so as to make a water-tight joint. It may be necessary in some cases to smooth the bark of an old tree with an axe or a knife before applying the tin box.

On finally removing the clamp after injection was completed, the wound was covered with grafting wax or painted.

Two conditions were found which greatly influenced the rate at which the trees took in the solutions when they were injected into the trunk. 1. The hole in the tree should be cut in such a way that air cannot get into it. 2. The hole should be clean cut. At first the holes were bored with freshly sharpened bits, but the solutions did not go in as rapidly as when a sharp chisel or gouge was used.

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EXPLANATION OF PLATE XIII

FIG. 1. Tin can method of injection.

FIG. 2. First step in Bovie's method of injection. *a*, A metal box open at top and at one end, made fast to tree with grafting wax and copper wire and filled with water.

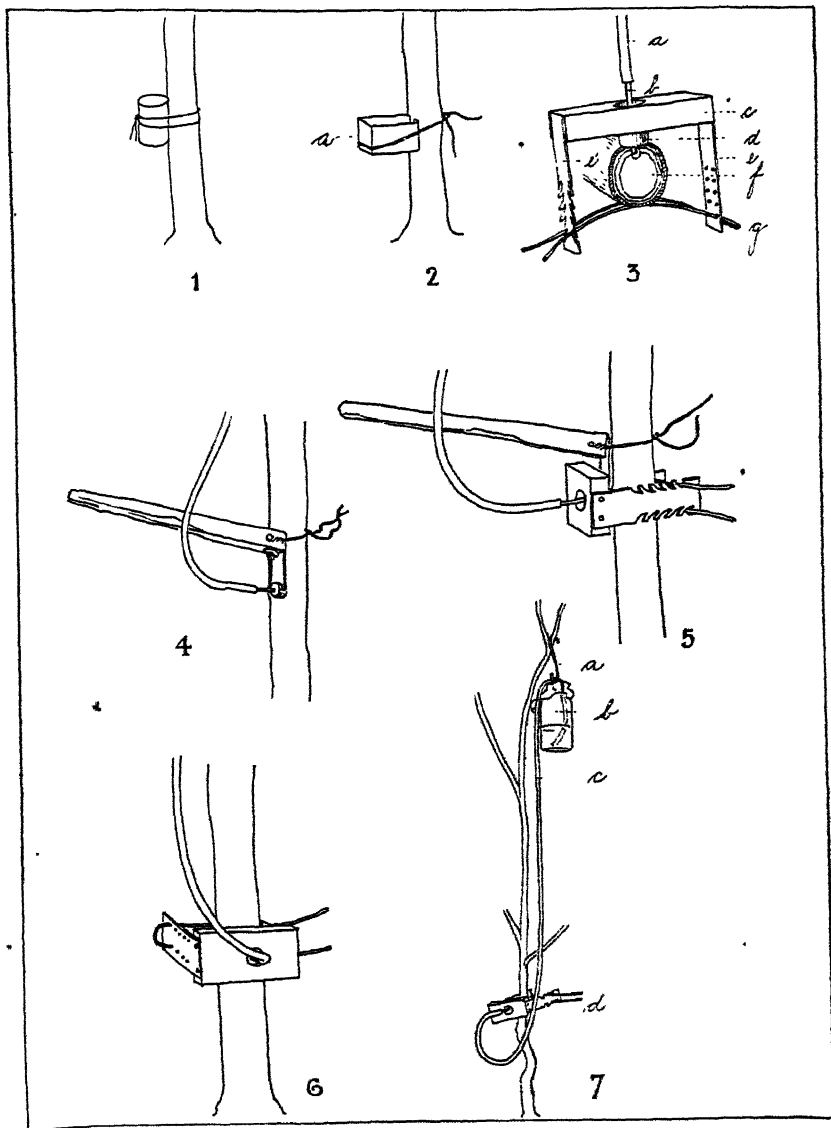
FIG. 3. View of clamp holding the tube in place at the point of injection. *a*, rubber tube leading solution to the tree; *b*, glass tube; *c*, *e*, *e'*, *g*, clamp (*c*, block of wood; *e*, *e'*, strips of metal; *g*, brass wire); *d*, rubber stopper; *f*, cross section of tree trunk.

FIG. 4. Bent lever holding the rubber stopper and tube in position, so that the clamp can be adjusted to the tree.

FIG. 5. Clamp adjusted to tree. Bent lever holding the rubber stopper in place.

FIG. 6. Front view of clamp; bent lever removed and preparations for injection complete.

FIG. 7. A tree being injected. *a*, Hook; *b*, jar containing the solution, capped with parchment paper; *c*, rubber tubing; *d*, clamp.



RUMBOLD: METHODS OF INJECTING TREES

RAZOUMOFSKYA TSUGENSIS IN ALASKA

JAMES R. WEIR

The mistletoe, *Razoumofskyia tsugensis* Rosend., which at present is known to attack only *Tsuga heterophylla* and *T. mertensiana* in the West recently has been sent to this laboratory from Alaska. The specimens were collected by Forest Examiner, G. L. Drake, on *T. heterophylla* near Tenakee, Chichagoff Island, Tongass National Forest. This is the first record of its occurrence in Alaska and extends its range practically to the most northern limit of its hosts. The late Mr. J. F. Pernot, United States Forest Examiner, supplied this laboratory with a specimen of *R. tsugensis* on *T. heterophylla*, labeled "vicinity of Lake of the Woods, Oregon." This is the farthest point south in the range of the host from which specimens have been procured. The writer has collected this mistletoe on *T. mertensiana* in the Coeur d'Alene Mountains, in Idaho, and *T. heterophylla* in several localities in Idaho, Washington and British Columbia. A collection on the latter host from the Lolo National Forest, east slope of the Bitterroot Mountains, Montana, extends the range of the parasite farther to the east than has been reported heretofore. It may be assumed that *R. tsugensis* extends throughout the entire range of its two known hosts. So far as known, it is of economic importance only in certain districts of Washington, Idaho and Alaska. Mr. Drake states that in some sections of the Tongass National Forest "the percentage of infection varied from 30 to 80 per cent of the stand" and is a serious menace to the best growth of the hemlock forests. Injury to the host results from the formation of large burls on the trunk, also the branches become heavily broomed which causes them to break off under the stress of high winds or snow. This causes a serious retardation of growth and exposes such trees to attacks by fungi and insects.

INVESTIGATIONS IN FOREST PATHOLOGY

BUREAU OF PLANT INDUSTRY

MISSOULA, MONTANA

THE CONTROL OF CEREAL AND GRASS SMUT AND THE HELMINTHOSPORIUM DISEASE IN HOLLAND AND GERMANY

OTTO APPEL

Quanjer and Botjes¹ have published the results of new experiments on cereal and grass smuts and the Helminthosporium disease and have come to the conclusion that spraying with a solution of 200 grams copper sulphate per 2 to 2.5 liters of water for each hectoliter of wheat seed, gives the best results in the control of stinking smut. The authors are wrong, however, in saying that this method is impractical in Germany. On the contrary, it is much used. It is not recommended, however, because under the conditions prevailing in Germany, it has some disadvantages. One of these is that in dry summers the wheat is so brittle that in threshing the kernels are cracked and such kernels are slightly injured by the copper sulphate. To prevent this the seeds are afterward treated with milk of lime. According to Quanjer, a smaller amount of a strong solution causes less injury than a larger quantity of a weak solution, which explains, perhaps, the failure of this method in many earlier experiments. The other and more important reason why this method is not recommended in Germany is the lack of success in many cases. With wheat with a thin seed coat the diseased kernels are all or nearly all crushed by threshing, and as a result the smut spores are scattered all over the surface of the sound seeds and are, therefore, easily killed by this method of treatment. On the other hand, with wheat having a harder seed coat the diseased kernels are not crushed and therefore the copper sulphate does not penetrate beneath the surface and kill the spores. When sown with a machine these kernels are crushed and the uninjured spores cause a new infection of the treated seeds. Since we, in Germany, use many varieties of wheat with hard seed coats, the spraying method is not universally applicable and therefore methods are to be recommended in which either all the entire diseased kernels are floated out before treatment as in v. Tubeuf's method, or in which substances like formaldehyde are used, which act more upon the spores in the interior of the kernels.

¹ Quanjer, H. M. en Botjes, I. Oortwijn. Nederlandsche onderzoekingen over de bestrijding van Grann-en Grasbrand en ven Strepenziekte. Mededeelingen van de Rijks Hoojere Land-, Tuin- en Boschbouwschool, 8: H. 26, 129-160, pl. III-V. 1915.

The formaldehyde treatment gives good results in general in Germany, while Quanjer had less success with it. In the first place Quanjer found that the young plants developed more slowly after the formaldehyde treatment. This seeming injury appears to me to be due to the fact that the seed which Quanjer has used was not normal. In the untreated plots of the three winter wheats used (Wilhelmina, Witte Dikkopp, and Grenadier), only 21, 10, and 28 per cent germinated in the soil; of the summer wheat 78 per cent germinated between blotting papers and 50 per cent in the soil. But it is well known that bad seed is more sensitive than good seed. For this reason we generally use in Germany wheat which has a germination percentage of 98 to 100. Wheat, less than 90 per cent of which germinates, is used by us only in case of necessity. That poor seed is less injured by copper, especially in the form of Bordeaux mixture, than by formaldehyde is shown by our experiments.

The good results with formaldehyde have been confirmed in 1914, both in practice and by the experiments carried on by my collaborator, Dr. E. Riehm.² When we try new control measures in Germany, it is not because, as Quanjer assumes, our former methods were unsatisfactory, but in order to determine the value of new fungicides recommended by commercial houses, and also for the purpose of finding a means of combatting several diseases at the same time, as in the case of *Tilletia tritici* and *Fusarium* on wheat and rye and *Ustilago tecta* and *Helminthosporium* on barley.

Riehm's experiments have proved that a treatment of the seeds by a 0.1 per cent solution of mercuric salt of monochlorophenol (chlorphenolquecksilber) for ten minutes is as effective as formaldehyde against stinking smut, but anilin dyes and chinisol are less satisfactory.

Chlorphenolquecksilber and chinisol may be used with good results in case of a light attack by *Helminthosporium*; in the severe attack occurring in 1912, copper sulphate was more effective than formaldehyde but did not stamp out the disease entirely.

For the control of *Fusarium* all the fungicides are equally effective, i.e., a submersion of the seed for 15 minutes in a 0.1 per cent solution of formaldehyde, chinisol, corrosive sublimate, or chlorphenolquecksilber. This treatment only diminishes the disease, however. The effectiveness of the treatment depends upon the amount of penetration of the fungus into the seed. If infection has taken place during the milk stage, or when mature seed has been subjected to an extended period of excessive moisture, then no chemical means of prevention are effective so far as known.

² Riehm, E. Beizversuche zur Bekämpfung einiger Getreidekrankheiten. Illustr. landw. Ztg. 35: 161-162. 1915.

For America, with its enormous wheat fields, Quanjer's method is to be recommended on account of its simplicity, when the wheat contains no unbroken smut kernels. I would rather recommend, however, Tubeuf's method, using Bordeaux mixture instead of copper sulphate because these less readily soluble copper salts act longer than the easily soluble copper sulphate.

The Danish hot water method in its modified form is, according to Quanjer, of value as a preventive measure against *Ustilago nuda*, *U. hordei*, *U. tritici*, *U. avenae*, *U. bromivora*, and *Helminthosporium*. I call attention to the fact here that in Germany we have obtained striking results with formaldehyde in the prevention of oat smut which does not attack the flowers but infects the seedlings. Naturally, the formalin treatment cannot be used in the case of smuts attacking the flowers.

BERLIN-DAHLEM

GERMANY

THE CHESTNUT BARK DISEASE ON FRESHLY FALLEN NUTS

J. FRANKLIN COLLINS

WITH ONE FIGURE IN THE TEXT

The writer has called attention¹ to the finding of the chestnut bark disease on old nuts and burrs of the Paragon chestnut, in Lancaster county, Pennsylvania, in 1912. This discovery suggested the possibility that the disease might at times be found in freshly fallen nuts, but no opportunity occurred until the fall of 1913 to examine fresh nuts grown in a region where the disease was prevalent.

In Delaware, on October 23 and 24, 1913, freshly fallen nuts of several cultivated varieties were found which had well-marked blister-like excrescences (fig. 1) under the tough outer skin. Several nuts showing these excrescences were found under two Ridgely trees near Dover, and under one Ridgely, one "Spanish," one Numbo, and one Dager tree at Felton. Under one tree some of the diseased nuts were still attached to the opened burrs, and in one case they were found in a burr which had not yet fallen from the tree.

Cultures were attempted from all six of these sources, mainly from the interior of the blister-like excrescences. Although a rather hasty examination of the kernel of one nut from each of the six sources mentioned revealed fungal hyphae in five of them, no attempt was made to get cultures. No cultures were obtained from the excrescences on the nuts of one Ridgely tree, and the cultures from the Dager and "Spanish" nuts became contaminated, or were not typical, and were discarded. Cultures from the other three nuts—obtained from (a) the original old Ridgely tree near Dover, (b) a young Ridgely tree at Felton, and (c) a Numbo tree at Felton—resembled typical pure cultures of the chestnut bark disease fungus, *Endothia parasitica* (Murr.) And.

Inoculations were made from the three cultures last mentioned. Those from the old Ridgely tree and the Numbo tree were made on May 26, 1914, and those from the Ridgely tree at Felton on July 31, 1914. The method of inoculating was the same in each case; nine cuts were made along the side of an American chestnut sprout, the three lowest to the wood, the next three to the middle bark, and the upper three were little

¹ Science 38: 857-858. December 12, 1913.

more than scratches through the outer layers of the bark. No attempt was made to inoculate with spores alone, nor with mycelium alone; undoubtedly all inoculating media contained both. Nine check cuts with a sterile knife were made on the opposite side of each sprout, one cut opposite each inoculated cut, and practically identical with the latter as regards depth and character of cut. The usual precautions were taken to have the knife and other implements sterile.

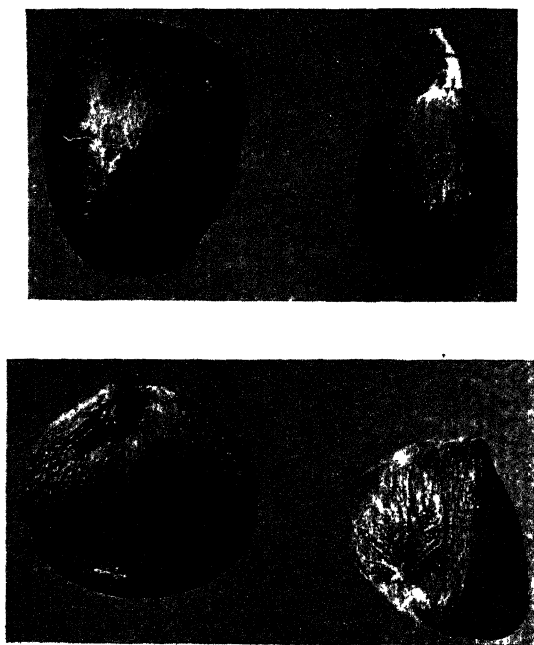


FIG. 1. Four cultivated chestnuts showing blister-like excrescences of the chestnut bark disease. Natural size.

At the date of the last observation, January 8, 1915, the six lowest cuts in each series of inoculations had developed typical lesions of the chestnut bark disease, varying from one to four inches in diameter, while the three upper cuts (scratches) and all the check cuts failed to show any signs of disease.

The failure of attempts to inoculate through scratches in the surface of the bark has been a noticeable feature of similar attempts in the past, although they have not always been as definite and well-marked as in the present instance.

The results mentioned above may be summarized and tabulated as follows:

NAME OF VARIETY	INOCULATIONS	CHECKS	RESULTS
Ridgely (old tree)	3 to wood 3 to middle bark 3 scratched	9	all infected all infected none infected none infected
Numbo	3 to wood 3 to middle bark 3 scratched	9	all infected all infected none infected none infected
Ridgely (young tree)	3 to wood 3 to middle bark 3 scratched	9	all infected all infected none infected none infected

The data obtained from these cultures and inoculations show conclusively that nuts are sometimes infected with the chestnut bark disease before they fall from the tree. . Most of the nuts collected in 1913 had considerably fewer and less conspicuous blister-like excrescences than the four shown in the accompanying illustration. Otherwise, as viewed externally, they appeared to be normal and healthy, and undoubtedly would readily be passed by the ordinary shipper as sound and marketable nuts. Under such conditions it would be within the range of possibility to introduce the disease into a new locality by means of the discarded shells or kernels of the diseased nuts.

LABORATORY OF FOREST PATHOLOGY

U. S. BUREAU OF PLANT INDUSTRY

BROWN UNIVERSITY, PROVIDENCE, R. I.

PHYTOPATHOLOGICAL NOTES

A way of obtaining an abundance of large uredinia from artificial culture. While engaged in wheat rust cooperative work with the Office of Cereal Investigations, Washington, D. C., a most satisfactory method was found for propagating rust cultures on an extensive scale. When one is engaged in a particular line of rust investigational work which requires an accumulation of uredo-material for spraying purposes, the material which is required must be produced in considerable quantities, and this requires a great deal of time and patience. Since the rust must be grown upon the host itself, it is desirable that each inoculation produce an abundance of sori, and that these be as large as possible.

Ordinarily, hand inoculations are made by scraping the spores from a leaf bearing them, using a flattened needle moistened in distilled water. The spores are generally placed in a drop of water which is attached to the back of the leaf blade near its base. Those who have been engaged in this kind of work realize the difficulty involved in attaching this drop of water, or in wetting the surface of the leaves of grasses sufficiently to get the spores to adhere. This method is a tedious one, especially when it is necessary to make hundreds of inoculations. The writer has also observed that the sori which develop from the attached drop method are often very limited in size and number.

The method which we have followed in propagating *Puccinia graminis tritici* on a large scale for field spraying purposes, where the testing of wheats resistant to the black stem rust is carried on, is as follows: Potted wheat seedlings from a few days up to two weeks old are employed. In addition to these, a dish of distilled water, a curved dissecting needle, or a flattened needle, and viable uredospores, are the necessary materials. The surfaces of the leaves to be inoculated are thoroughly wetted by passing the leaf blades between the thumb and index finger which have been dampened in the dish of water. Pass the leaves between the thumb and finger several times so as to cause a film of water to adhere to the entire leaf surface. By means of the transferring needle, apply the spores from the material bearing them, to the upper surface of the leaf to be inoculated. Pass the needle back and forth over the entire surface so as to spread the spores over the leaf blade. It is more convenient to inoculate the under surface of wheat leaves and the results are very satisfactory. Although there are only half the number of stomata on the

under surface, in the case of wheat, there seems to be little difficulty in securing an abundance of infection.

Inoculated plants should be immediately placed into damp chambers in the ordinary manner, and allowed to remain there for forty-eight hours. At the end of this time they should be removed and placed on a greenhouse bench containing soil or preferably sand.

The sand and potted plants should be kept damp. It is found that galvanized iron trays, 35 inches x 17 inches x $\frac{1}{2}$ inch are most satisfactory to set the seedlings into after having come out of the damp chamber. These pans can be flooded with water and in this way there is no danger in losing the uredospores in watering, for it is possible to water the pots without touching the leaves.

It is not necessary to supply shade, unless it becomes very bright. It generally requires from ten days to two weeks for sori to appear. Although this method would not be advisable or satisfactory where one wishes to eliminate all possible chances of contamination, it is the only practical method for growing rust material on an extensive scale, for such purposes as mentioned above. In using the above method, the writer never failed to secure an abundance of large sori which extend over the entire leaf surface.

LEO E. MELCHERS

Sweet pea powdery mildew. • The appearance of a recent bulletin on the diseases of the sweet pea, by Taubenhaus¹ in which the powdery mildew of the sweet pea is referred to as "*Erysiphe polygoni*?" leads the writer to state that on September 27, 1910, he collected from the horticultural garden of the College of Agriculture, Ithaca, N. Y., leaves of the sweet pea which bore perithecia of *Microsphaera alni* (Wallr.) Salm. Many of the perithecia were immature with the appendages not well developed so that they might easily be mistaken for *Erysiphe polygoni*. A number of mature perithecia were found, however, typical in all respects of *Microsphaera alni*.

The writer has also had the privilege of examining an excellent specimen in the collection of the New York (Geneva) Experiment Station, which was collected by John L. Sheldon at Lincoln, Nebraska, in October, 1902, and determined by him as *Microsphaera alni* (Wallr.) Salm. on *Lathyrus odoratus*.

F. M. BLODGETT

¹Taubenhaus, J. J. The diseases of the sweet pea. Delaware Agr. Exp. Sta. Bul. 106: 38-40.

Personals. Mr. Max W. Gardner, of the University of Wisconsin, has been appointed as Field Assistant in Pathology in the Bureau of Plant Industry and will be stationed at Princeton, Wisconsin, to conduct co-operative cucumber disease investigations. Corresponding positions in Michigan and Indiana will be taken by Mr. Raymond C. Rose, of Minnesota, and Dr. Geo. A. Osner, of New York, with headquarters at Big Rapids, Michigan, and Plymouth, Indiana.

Mr. J. T. Rogers was transferred on March 25, 1915, from the position of Agent in Forest Pathology, Bureau of Plant Industry, to that of Assistant Pathological Inspector, Federal Horticultural Board.

Dr. F. L. Stevens, Professor of Plant Pathology, of the University of Illinois, is engaged during the summer in a Biological Survey of Porto Rico, collecting and studying tropical plant diseases and fungi. He sailed June 5 accompanied by Mrs. Stevens and by several students.

W. Ralph Jones. The death is announced of Dr. W. Ralph Jones, Scientific Assistant in Plant Pathology, Office of Fruit Disease Investigations, Bureau of Plant Industry, which occurred on May 17, 1915, at the age of 32 years. Dr. Jones graduated from the collegiate department of Johns Hopkins University in June, 1911, and had previous to that time been a teacher in the Baltimore City College, and in the Louisiana Industrial Institute, Ruston, Louisiana. He entered the Department of Agriculture in 1911 and had since that time been engaged with Dr. C. L. Shear in a study of the diseases of small fruits. He was a member of the American Phytopathological Society.

LITERATURE ON AMERICAN PLANT DISEASES¹

COMPILED BY MISS E. R. OBERLY, LIBRARIAN, BUREAU OF PLANT INDUSTRY

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¹ This list aims to include the publications of North and South America, the West India Islands, and islands controlled by the United States, and articles by American writers appearing in foreign journals.

All authors are urged to coöperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agric., Washington, D. C.

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PHYTOPATHOLOGY

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EFFECT OF TEMPERATURE ON GLOMERELLA

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WITH FOUR FIGURES IN THE TEXT

Among the factors which regulate the distribution and severity of plant diseases in tropical and sub-tropical climates is that of a continued high temperature. Very little is written concerning the effect of high temperature on the development of plant diseases and it is doubtful if this factor receives the consideration that it should. However it is interesting to note that recently Miss Westerdijk¹ has called attention to the fact that plant diseases are not abundant in the tropics. This is particularly interesting as it bears out many results obtained in Louisiana which are contrary to the common opinion that warm weather and a high humidity are the best conditions for disease development. In Louisiana, there is both the high temperature and high humidity and there has been a good opportunity to study the effect of these on the development of various diseases. The southern part of Louisiana has a sub-tropical climate with a short, comparatively cool winter, and a long summer with continued high temperature. While the heat of the summer is not excessive, there is a period from the last of May until the last part of September in which the minimum temperature is rarely under 70° F. and the daily maximum rarely under 90° F. This gives a considerable period in which vegetation is subjected to a continued high temperature.

There are, of course, many diseases which develop and spread during the hottest weather of the summer in Louisiana. These include the various wilt and root rot diseases, and many leaf troubles such as the angular leaf spot of cotton, the various *Cercospora* diseases, and so forth. Then there are diseases which are common in more northern climates during the summer season that develop satisfactorily in Louisiana only during the cool winter or spring months. These are represented by such

¹ Westerdijk, Johanna. Phytopathology in the tropics. Ann. Missouri Bot. Garden 2: 307-313. 1915.

diseases as the onion mildew which attacks the plants during the winter and spring months and then lies dormant during the summer, and by the bean anthracnose which develops on the spring crop of beans and dies out entirely during the summer months. Finally, there is a third class of diseases, a group common in northern states, that does not occur in Louisiana or at least but sparingly. In this group may be placed such diseases as the sycamore anthracnose, caused by *Gnomonia veneta*, and most of the diseases caused by members of the Erysiphaceae. The sycamore anthracnose, although abundant in the northern states, apparently does not occur in Louisiana. The host is abundant and other than the high temperature of the summer, conditions would seem to be ideal for the development of the parasite. The whole group of the Erysiphaceae are very uncommon in Louisiana. Specimens of powdery mildews are only occasionally collected and then only in the winter and early spring.

PREVIOUS INVESTIGATIONS

In previous publications by the writer² on the bean anthracnose disease, the effect of a high temperature on the development of the causal fungus has been pointed out and discussed. Field studies carried through several years showed conclusively that this fungus would not develop during the hot summer months in Louisiana. The disease develops abundantly on the spring crop of beans, if diseased seed is used for planting; but if the seed is planted in August, as is necessary if a fall crop of beans is desired, the disease does not appear and the pods remain perfectly healthy. This fact is of considerable importance from an economic standpoint as a crop of clean beans can be raised in the fall which can be used for planting the main crop in the spring.

OBJECTS OF THE INVESTIGATION AND METHODS EMPLOYED

From the results obtained in the field work, it seemed desirable to continue the investigation and to test the bean anthracnose fungus carefully under laboratory conditions with all of the varying factors under control. The rate of growth at different temperatures and the optimum and maximum temperatures seemed to be important points in order to understand the life history of the fungus and the development of the disease. It also seemed desirable to test in the same way various other strains of the genus *Glomerella* for comparison. Many of the strains

² Edgerton, C. W. The bean anthracnose. Louisiana Agr. Exp. Sta. Bul. 119. 1910.

Edgerton, C. W. The bean blight and preservation and treatment of bean seed. Louisiana Agr. Exp. Sta. Bul. 139. 1913.

of *Glomerella* are very closely related and it seemed possible that the temperature factor might be helpful in separating the different ones. Data on the fungus causing the apple anthracnose or bitter rot disease also seemed to be of importance as previous investigations by different workers had shown that there are probably two distinct forms with different temperature requirements on the apple.

In order to procure the desired data, forty-nine cultures of *Glomerella* from twenty-two different host plants were obtained. The majority of the cultures came from Louisiana, but there were a number from other parts of the country and from the tropics. The host plants and the number of cultures from each host were as follows: apple (8), bean (10), lima bean (1), orange (3), banana (2), watermelon (2), American persimmon (2), Japanese persimmon (1), cotton (3), sugar cane (1), fig (3), blackberry (2), pecan (1), *Ficus elastica* (1), *Oxyanthus isthmia* (1), *Ipomoea purpurea* (2), *Solanum carolinense* (1), *Passiflora incarnata* (1), *Desmodium tortuosum* (1), *Melia azederach* (1), *Narcissus* sp. (1), *Sambucus canadensis* (1). These cultures represented practically all of the common types of *Glomerella* that are found in this country. A number of these were ascogenous cultures while the rest produced only the *Gloeosporium* or *Colletotrichum* stage. Both the plus and minus strains³ of two forms were used, these being from blackberry and from *Ipomoea purpurea*.

These different cultures were grown at various temperatures ranging from 14°C. to 37.5°C. For the temperatures between 14° and 31°, a Hearson low temperature incubator was used, while an ordinary bacteriological incubator was used for the higher temperatures. The cultures were grown in petri dishes on agar made from bean pods. All the agar used was made at one time to eliminate all chance of variation in the medium. Three plates were made of each culture. A small bit of mycelium from the edge of a rapidly growing colony was transferred to the center of each plate. All of the plates of all of the cultures were placed in the incubator as soon as they were made and allowed to develop for five or six days. Every twenty-four hours, the diameter of each colony was measured. The daily growth of the colony was then obtained by averaging the increase in diameter for the last three or four days. The growth of the first twenty-four hours was never considered. Sets of plates were incubated at 14°, 16°, 19°, 21°, 23°, 25°, 27°, 29°, 31°, 33.3°, and 37.5°C. In any test where there was any question, either on account of contamination or for other reasons, duplicates were made as checks. Also sets were incubated at the same temperature at different times

³ Edgerton, C. W. Plus and minus strains in the genus *Glomerella*. Amer. Jour. Botany 1: 244-254. 1914.

in order to make certain that the cultures were not deteriorating or that the rate of growth was not changing. No culture that showed signs of "running out" or of deterioration was used in the tests.

The results of these tests will be shown by curves as space does not permit the tabulation of all of the figures that were obtained. The curves show the daily growth, or actual increase in the diameter of the colony in millimeters at any given temperature, and also the optimum and maximum temperatures for growth of each culture. The curves also aid in determining the similarity or dissimilarity of the different forms.

COMPARISON OF CURVES OF GROWTH

In figure 1 is shown the growth curves of thirty different cultures of *Glomerella*. While there were nineteen more cultures in the tests, these all came within the group designated in the figure as *b* and it did not seem necessary to add these to the already crowded figure. An examination of these curves will show two important things. There is a great difference among the forms in regard to temperature, a difference in the rate of growth and in the optimum and maximum temperatures. Also the curves of all of the forms studied fall readily into six well defined groups, marked *a*, *b*, *c*, *d*, *e*, *f* in the figure.

In group *a*, are shown the curves of growth of two different cultures of the fungus of banana anthracnose, *Gloeosporium musarum*. One of these had been growing on culture media in the laboratory for over a year before the experiments started, while the other one was isolated just as the work commenced. Cultures of the banana form grow much more rapidly than any of the others and the optimum temperature for growth is also higher. At the optimum temperature of 29° to 30°C., the colony increased in diameter nearly 22 mm. in 24 hours. There is practically no difference in the growth curves of the two cultures.

In group *b* fall the greatest number of the cultures from the various hosts studied. In this group are the cultures from *Oxyanthus isthmia*, *Ipomoea purpurea*, *Ficus elastica*, *Solanum carolinense*, *Passiflora incarnata*, *Desmodium tortuosum*, *Melia azederach*, *Narcissus* sp., *Sambucus canadensis*, orange, cotton, sugar cane, fig, blackberry, Japanese persimmon, one of the cultures from the American persimmon, part of the apple cultures, and some saprophytic forms from bean. The optimum temperature for all of these was between 27° and 29°C. The maximum rate of growth was from 11 to 14 mm. per day. The maximum temperature was above 37.5°C. In this group are found the forms which commonly produce the perithecial or ascogenous stage. Many of the cultures that were used in this experiment were producing perithecia abundantly, including all three

of the apple cultures which fell in this group. The fungi in the group showed many differences in regard to such characters as the relative abundance of conidial masses, color of mycelium and culture medium, and so forth, yet the cultures of all showed a scanty development of aerial mycelium. In this group, apparently, would be found most of the

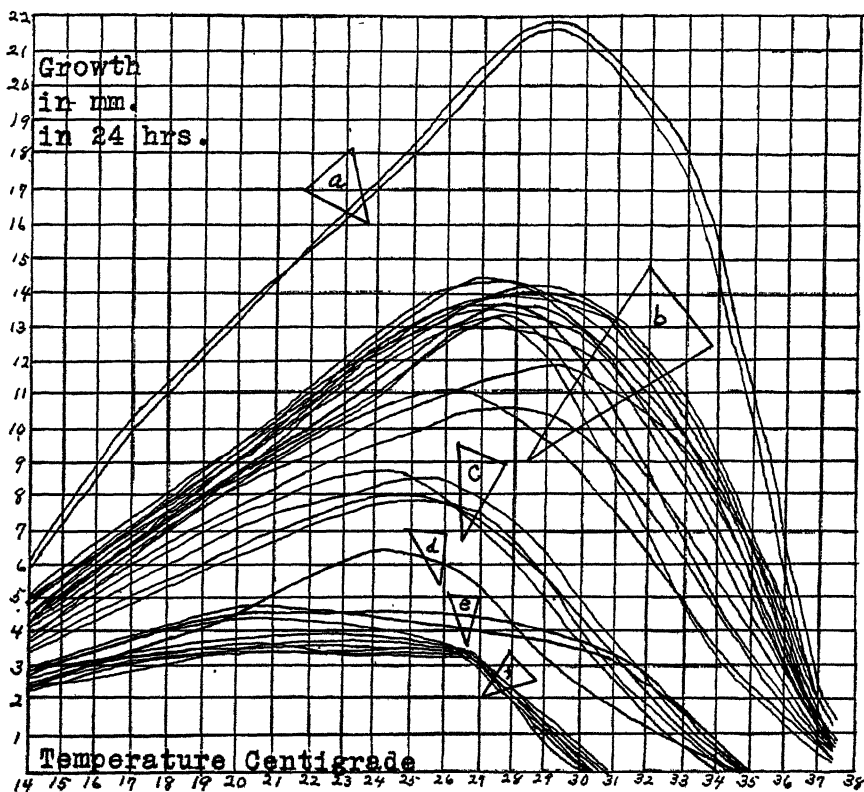


FIG. 1. Curves of growth of 30 different cultures of *Glomerella* at varying temperatures. (a) *Gloeosporium musarum*. (b) *Glomerella cingulata*, *Glomerella gossypii*, and related forms. (c) *Gloeosporium fructigenum*. (d) A slow-growing form from apple. (e) *Colletotrichum lagenarium*. (f) *Colletotrichum lindemuthianum*.

forms that are so common on dead and dying parts of various plants and also many of the true disease producing forms.

In group c are three cultures from the apple and one from the American persimmon. These were cultures of the fungus that is so common on apples and various other fruits and vegetables in the northern states. While this fungus occurs to some extent in the south, it is not so common

as in cooler climates. The optimum temperature for growth is about 25°C. and the maximum between 34° and 35°C. The maximum rate of growth at the optimum temperature on the medium used was from 8 to 9 mm. per day. Besides the reaction to temperature, cultures of this fungus, on the medium used, differ from those in group *b* by the comparatively dense development of pure white aerial mycelium. As far as the experience of the writer goes, cultures that would fall in this group do not produce perithecia. Many cultures of apparently the same fungus as was used in these tests, from many host plants and from many places, have been studied within the past several years but in no case have perithecia been observed.

In group *d* is found a single culture from apple. This had an optimum temperature for growth of 25°C. and a maximum of about 34°C. The increase in diameter at the optimum temperature was between 6 and 7 mm. per day. This was a very peculiar culture and from all appearances it was growing saprophytically on the apple and had no relation to the true apple anthracnose. The culture was very black in color, approaching the fungus of bean anthracnose in appearance. The spores developed very profusely and were identical in appearance with other spores of anthracnose fungi. As far as known, no other worker has had such an appearing culture from the apple. The culture was isolated from an apple sent from New York State.

In group *e* are two cultures of *Colletotrichum lagenarium*, cause of the anthracnose of watermelon. One of the cultures came from Delaware and the other from Louisiana. The optimum temperature for growth for this fungus was about 24°C. and the maximum temperature about 35°C. The increase in diameter of the colony at the optimum temperature was between 4 and 5 mm. per day. Cultures of the watermelon anthracnose fungus are characterised by the lack of a dark color and by the slimy development of spores. The spores developed so abundantly on the bean agar that a slimy pink covering was formed on the surface. Perithecia of this fungus have never been found.

In group *f* are cultures of the bean anthracnose fungus, *Colletotrichum lindemuthianum*. Eight different cultures were used in order to test any possible individual variation. These cultures came from different varieties of beans and from different parts of the country. The optimum temperature of growth for this fungus is somewhere around 22° to 23°C. though there is but very little difference in growth at temperatures between 19° and 26°C. The maximum temperature is between 30° and 31°C. The rate of growth at the optimum temperature was between 3 and 4 mm. per day. Cultures of the bean anthracnose fungus are characterised by their slow growth and by their very black color.

The relation of growth to temperature as shown by these curves throws considerable light on the distribution and destructiveness of some of the members of the genus *Glomerella* in different parts of the country. The fungi represented in groups *a* and *b* are very common in the southern states. They grow well at ordinary temperatures and will grow under a continued high temperature. The fungi in group *c* occur in the south

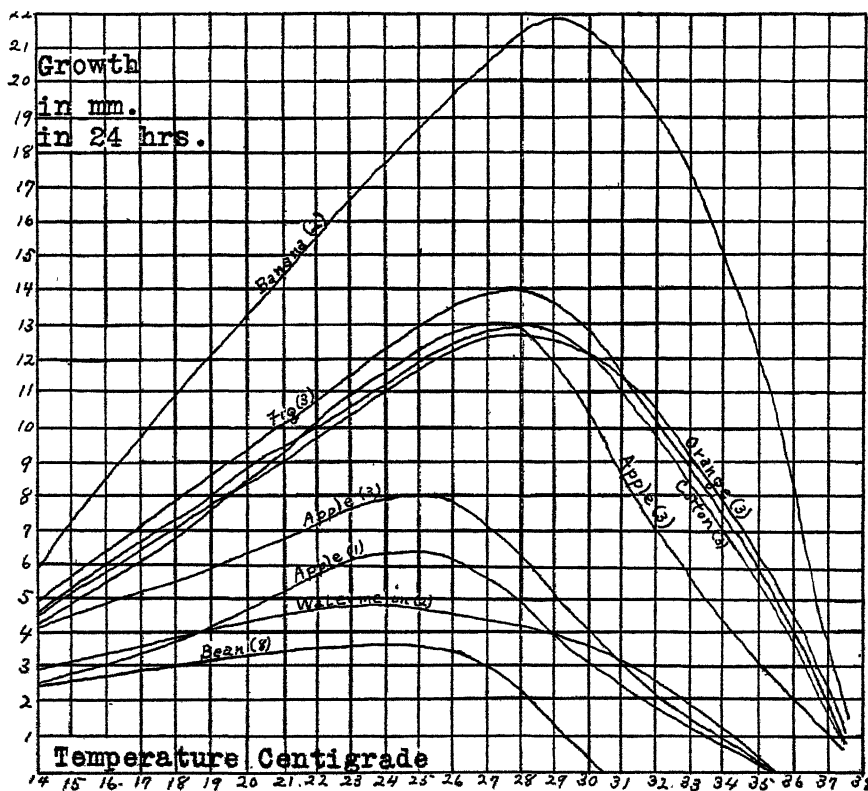


FIG. 2. Curves of growth of *Glomerella* cultures from several hosts. The figures in parentheses show the number of cultures that were averaged to form the curves.

but are more common and destructive in the north. The fungi in groups *e* and *f* do not thrive in the summer temperatures of the south. The watermelon anthracnose is not abundant in the south and there is practically no damage. In fact, only one specimen of this disease has been received at the Plant Pathology Laboratory in Louisiana in seven years. The bean anthracnose fungus will develop abundantly in the south in the spring during the cooler weather but is entirely killed out during the

summer months. It is interesting to note that it is even very difficult to keep a culture of *Colletotrichum lindemuthianum* alive in the laboratory during the summer season in Louisiana unless an ice box is available.

In order to show more clearly the relation of the several *Glomerella* forms to temperature, the curves of growth of several forms from different hosts are shown in figure 2. Each curve is made by averaging all the results obtained from like cultures from a single host; for instance, the curve representing the bean anthracnose has been made by averaging the curves of eight different cultures. The figures in parentheses after the host plant names, indicate the number of cultures used to make each curve. These show clearly the difference of the different forms in their reaction to the temperature factor. The curves also show why the bean anthracnose fungus will not live through the summer in the south and why the watermelon fungus and one of the forms from the apple are not common in that section of the country.

Comparison of cultures from the same host

Among the points of interest which were brought out by these experiments is the fact that cultures from the same host, with a few exceptions, show a remarkable similarity in regard to their reaction to temperature. *Glomerella* cultures are often extremely variable and it would not have been surprising if there had been a considerable variation in regard to the reaction to temperature. In figure 1, the similarity of the curves of the different cultures of *Gloeosporium musarum*, *Colletotrichum lagenarium*, *Colletotrichum lindemuthianum* and the slow growing form from the apple are readily seen. The cultures of the fungi from cotton, orange and fig also show as striking a similarity.

Comparison of cultures from the bean

Cultures from the bean gave some interesting results and formed one of the exceptions mentioned in the preceding paragraph. Ten cultures from this host were used in the experiments and the growth curves are shown in figure 3. In the figure are seen the eight similar curves of *Colletotrichum lindemuthianum* near the base line, the same as are shown in figure 1. Also the curves of two cultures are illustrated which show more rapid growth and higher optima and maxima temperatures. These two curves fall in group *b* described above. While these two cultures came from beans, it is certain that they do not belong to the species, *Colletotrichum lindemuthianum*. They have entirely different cultural characters and furthermore do not cause an infection on growing beans.

In the southern states almost any species of plant, after the tissue becomes old and has lessened vitality, will become infected with some of the forms of group *b*. Beans are no exception to this rule. These two organisms were evidently growing saprophytically on old bean tissue.

Of further interest is the fact that one of these rapidly-growing cultures from the bean is an ascogenous strain. It is doubtful if the perithecial stage of *Colletotrichum lindemuthianum*, the fungus causing bean anthracnose, has ever been seen. While hundreds of different cultures of this fungus have been made during the past few years, the writer has never seen any signs of perithecia in any of them. The asco-stage has been

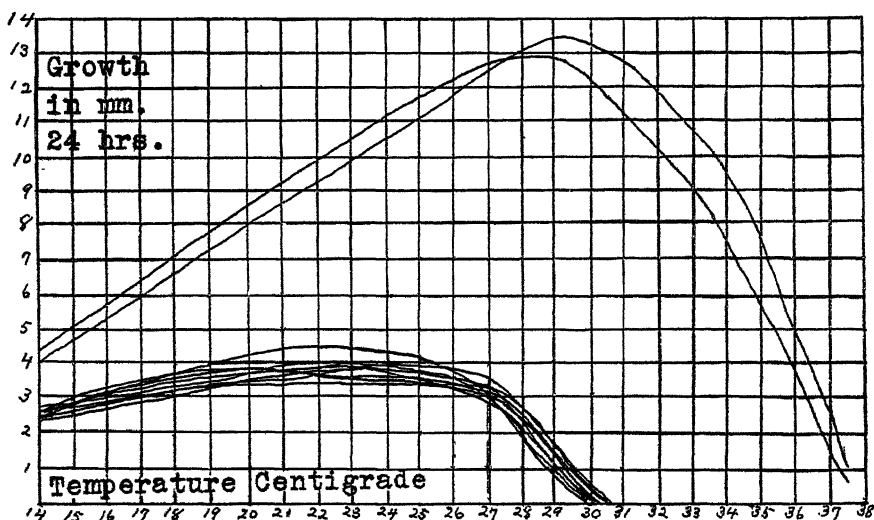


FIG. 3. Curves of growth of ten cultures of *Glomerella* isolated from bean. The curves near the base line represent the true bean anthracnose fungus, *Colletotrichum lindemuthianum*; the other two curves represent forms close to, if not identical with, *Glomerella cingulata*. The latter cultures were evidently accidental on the bean.

reported by Shear and Wood,⁴ but after a careful consideration of the data given, it seems very doubtful if they were working with a culture of the true bean anthracnose fungus. They obtained their culture from an old bean pod, and as has been shown above, other ascogenous anthracnose fungi may occur on such material. Furthermore, they obtained a culture which produced perithecia alone and did not produce conidia.

⁴ Shear, C. L. and Wood, Anna K. Ascogenous forms of *Gloesporium* and *Colletotrichum*. Bot. Gaz. 43: 259-266. 1907.

Shear, C. L. and Wood, Anna K. Studies of fungous parasites belonging to the genus *Glomerella*. United States Bur. Pl. Ind. Bul. 252. 1913.

Frequently in Louisiana during the past few years, such non-conidial producing organisms have been isolated from old parts of a number of different plants. Two or three of the cultures described in group *b* in this article produce perithecia only. As Shear and Wood performed no inoculation experiments with their ascogenous culture to prove pathogenicity, it seems more reasonable to suppose that they had a culture of *Glomerella* that was accidental on the bean and was not the true bean anthracnose fungus itself. If this is the case, perithecia of *Colletotrichum lindemuthianum* have as yet never been seen; and until some one proves definitely that they do occur, it seems better to consider the bean anthracnose fungus as a non-ascogenous form.

Comparison of cultures from the apple

In a previous article,⁵ attention was called to the fact that there seemed to be two different strains of the apple anthracnose, a rapid-growing southern form and a slow-growing northern form. This contention has not received serious consideration by many other workers as it is somewhat contrary to general opinion that not more than one strain should be found on a single host. In fact only two articles have been seen in which the existence of the two forms has been recognized. Lewis⁶ has called attention to the fact that cultures isolated in Maine are not as virulent as the southern form. Schneider-Orelli⁷ has investigated the apple anthracnose problem in Europe and has obtained some very interesting data. He obtained cultures from the United States and compared them with the European form. He found that the American form grew faster at the higher temperatures and also that the optimum and maximum temperatures were higher. The results which he obtained with the American form agree very closely with those of the rapid-growing form described in this article and it is evident that he had cultures of this fungus. From the data which he gives, it also seems very probable that the European form is identical with the American slow-growing form.

From the work of others and also from recent investigations, there seems to be no doubt that there are two distinct strains—probably species—occurring on apple in this country. The differentiating characters of the two forms are important and will be briefly described.

⁵ Edgerton, C. W. The physiology and development of some anthracnoses. Bot. Gaz. 45: 393, 402-403. 1908.

⁶ Lewis, Charles E. Apple diseases caused by *Coryneum foliicolum* Fekl. and *Phoma mali* Schulz et Sacc. Maine Agr. Exp. Sta. Bul. 170: 189. 1909.

⁷ Schneider-Orelli, O. Zur Kenntnis des mitteleuropaischen und des nordamerikanischen Gloeosporium fructigenum. Centralbl. Bakt. Paras. und Infektionskr. Abt. 2, 32: 459-467. 1912.

One form grows rapidly, has higher maximum and optimum temperatures, produces but scanty aerial mycelium in culture, produces cankers on apple limbs besides rotting the fruit, occurs principally in the southern warmer parts of the apple belt, and very commonly produces perithecia on the host and in culture. It is probable that this fungus is identical with forms found on a number of hosts. If it is identical with the one found on *Ligustrum*, as seems probable, it should be called *Glomerella cingulata*.

The other form grows slowly, has lower optimum and maximum temperatures, usually produces a greater abundance of white aerial mycelium

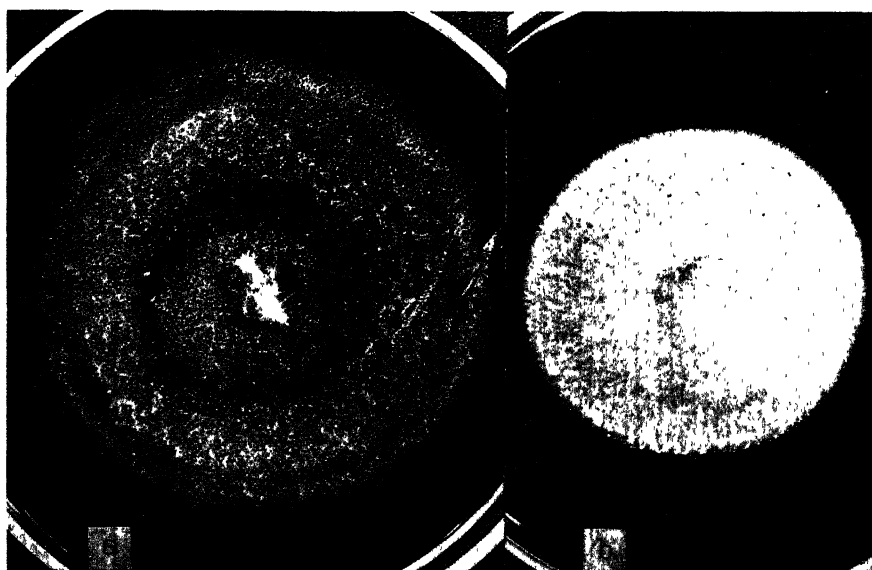


FIG. 4. Cultures of the two strains from apple, after six days of growth in bean agar at 27°C. (a) The rapid growing ascogenous form, *Glomerella cingulata*. (b) The slow-growing non-ascogenous culture, *Gloeosporium fructigenum*.

on most culture media, apparently does not produce cankers on apple limbs though it rots the fruit, occurs principally in the northern cooler sections, and apparently does not produce perithecia. From the standpoint of priority, it would be useless to try to find the proper name for this fungus as it occurs on a wide number of hosts and one cannot be sure which of the early descriptions refers to it. However, it is more than probable that Berkeley had this strain when he first described the apple rot, and for a lack of a better one, it seems well to use the name given by him, *Gloeosporium fructigenum*.

Comparison of cultures of other forms

The anthracnose fungi from watermelon and banana seem to be well marked species. Many different characters separate these from other forms and from each other. These are admitted to be distinct species by most workers in this group.

The fungi which have been described under group *b* represent the difficult ones from the standpoint of classification. These show a great many differences yet there are so many intergrading forms that it is impossible to separate them satisfactorily. Most of the forms without doubt should be referred to *Glomerella cingulata* but evidently not all of them. The form from cotton, *Glomerella gossypii*, seems to be fairly distinct from the others both from a morphological and a physiological standpoint and evidently should be considered a good species. Another form which has been previously mentioned, the one that produces ascospores and no conidia may also represent a distinct type, though the data are not as yet sufficient to show whether this is a constant character or whether it is a variation that may occur in many forms. There may also be a few other types which should be considered distinct but the evidence is not as yet clear.

CONCLUSIONS

Briefly the conclusions which have been reached in this paper may be stated as follows:

1. Regarding the reaction to temperature, the forty-nine cultures from twenty-two different host plants that were studied readily fall into six different groups as follows: (a) The form from banana, *Gloeosporium musarum*, a rapid-growing fungus, optimum temperature 29° to 30°C., and maximum temperature above 37.5°C.; (b) Forms from various hosts represented by *Glomerella cingulata* and *Glomerella gossypii*, forms with slower growth than the banana anthracnose fungus optimum temperature 27° to 29°C., and maximum temperature above 37.5°C.; (c) The form from apple and other hosts common in cooler climates and perhaps best known by the name of *Gloeosporium fructigenum*, a form with slower growth than the preceding, optimum temperature 24° to 25°C., maximum temperature 34° to 35°C.; (d) A form from apple not related to the forms above, characterised by its slower growth, optimum temperature 24° to 25°C., and maximum temperature 34° to 35°C.; (e) The form from watermelon, *Colletotrichum lagenarium*, a form with slower growth than the preceding, optimum temperature 24°C., and maximum temperature 34° to 35°C.; (f) The form from bean, *Colletotrichum lindemuthianum*, the

form with the slowest growth of any, optimum temperature 21° to 23°C., and maximum temperature 30° to 31°C.

2. The ascogenous forms of *Glomerella* seem to be confined to the groups having the most rapid growth, most of them falling in group *b*.

3. There are apparently two distinct anthracnose fungi found on apple in the United States. These are readily separated by the temperature reaction though there are other differences.

4. The bean anthracnose fungus, *Colletotrichum lindemuthianum*, will not tolerate a high temperature. This fact is utilized in the control of the disease in the warm regions of the country. Seed can be raised in the fall absolutely free of the disease and this can be used for spring planting.

5. A large number of forms from various hosts falling in group *b* cannot be separated by the temperature factor and it is probable that many should not be considered as distinct.

LOUISIANA AGRICULTURAL EXPERIMENT STATION

BATON ROUGE, LA.

RING-SPOT OF CAULIFLOWER

A. VINCENT OSMUN AND P. J. ANDERSON

WITH FOUR FIGURES IN THE TEXT

Cauliflower in large quantities is shipped into eastern markets from California. Practically all the cauliflower from this source on the Boston market the latter part of March and early April was badly affected with a disease known in Europe as leaf spot and in Australia as ring-spot. No previous record of its occurrence in America has come to the notice of the writers. Since it has already caused considerable loss and bids fair to become an important disease here, as has been the case in other countries where it has been introduced, it has been made a subject of investigation by the writers. The work is still in progress, but this opportunity is taken to call the disease to the attention of pathologists.

Economic importance. Cabbage and cauliflower and some other Cruciferae are affected. In Europe the disease has attracted attention solely as a disease of cabbage. Cooke (1906) does not consider it a serious disease in England. In regard to its importance in Victoria, McAlpine (1901) writes: "Since it only occurs on the older leaves, and especially those which are already fading and withering, it is not regarded as of serious import. Still the outer and older leaves prematurely decay, and therefore the plant is bound to suffer from defective nutrition." Kirk (1906) takes a more alarming view of its inroads in New Zealand: "This troublesome parasite is undoubtedly greatly on the increase, and its attacks are becoming more virulent each year . . . , it is rapidly becoming the most serious pest that cabbage and cauliflower growers have to contend with." If this disease has but recently been introduced into America it is not possible to predict the course it will run here. We are all too familiar with diseases which are not particularly destructive in their native home but which cause great losses when brought to our shores.

Even if the damage to the crop while it is growing in the field is but slight,¹ a period of from twelve days to three weeks must elapse between the cutting of the cauliflower in California and the time it is placed on the market in Boston. Information obtained from Boston wholesale

¹ Prof. R. E. Smith, of the California Agricultural Experiment Station, informs the writers that this disease has not been observed in California.

dealers is to the effect that the consignors claim the cauliflower goes into the cars in a healthy, green condition. But although the cars are kept iced, conditions very favorable to the development of the disease evidently prevail during transit. In one car examined in the Boston freight yards the writers found three men employed solely to remove the diseased and yellow leaves from the outside of the heads in order to make them presentable on the market. One wholesale dealer estimates his loss from this trouble at from \$300 to \$400 per car. The problem in this country may be one of shipping and marketing rather than of growing the crop.

Symptoms. On the market only the leaves were found to be affected, but in Europe the pods of the cabbage are also said to become diseased. The outer leaves are much more seriously attacked than those near the center of the head. In light cases only a few spots occur on a leaf, and the leaves show no tendency to turn yellow. Other leaves have hundreds of spots on them, often so close that they coalesce (fig. 1). In the latter case the leaves turn yellow. Most of the spots are on the laminae, but the large midribs also may be affected. The spots are definite in outline, circular, average about 4 to 5 mm. in diameter (range from 1 mm. to over 1 cm.). They are visible on both surfaces of the leaf, have light brown or grayish dry centers, surrounded by olive-green or blue-green borders which shade off into the natural color of the leaf, but when the leaves have become yellow the lesions retain the green color and are very conspicuous against the yellow background. The green borders are often raised and may show a tendency to concentric circles. Very minute black dots, barely visible to the naked eye, cover the outer edges of the spots on both surfaces of the leaves. They are very densely crowded together in the outer parts of the lesion, but are either absent or more scattered in the central gray portion. After the leaves have stood for a while the dots also appear on the yellow tissue surrounding the spots. On the leaves collected here the minute points do not appear to be arranged in concentric circles, as has been reported in Europe by Grove (1914).

Causal organism. The disease and the fungus causing it have been known for nearly a century. Chevallier (1826) first described the fungus, giving it the name *Asteroma Brassicae*. From his description it is impossible to tell whether he observed the pycnidial or the perithecial stage. All subsequent students of the fungus apparently believe that he had only the former. Duby (1830) described the same fungus four years later as *Sphaeria brassicaecola*. Perkeley and Proome (1852) listed it as *Sphaeria Brassicae* and published a figure of the asci and ascospores. Evidently the latter were immature since they show no septa. Eight

years later Berkeley (1860) lists the fungus as *Sphaeria brassicaecola*. De Cesati and de Notaris (1863) changed the generic name and called it *Sphaerella brassicaecola*, giving also as a synonym *Dothidea Brassicae* Desmaz. (Ann. Sc. Nat. 1842, xvii). Saccardo (1882) gives as the correct name *Sphaerella brassicicola* (Duby) Ces. et de Not. He does not

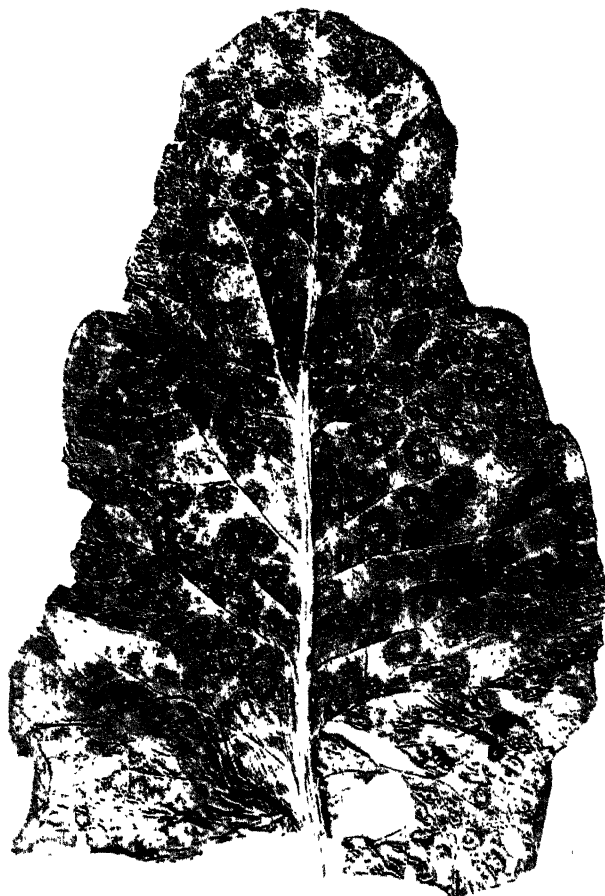


FIG. 1. Cauliflower leaf badly affected with ring spot. One-fourth natural size.

explain why he changed the spelling of the specific name. Duby and Cesati and de Notaris give *brassicaecola*. Lindau (1897) calls attention to the fact that the generic name *Sphaerella* must be discarded because it was previously applied to a genus of the Volvocaceae. He recommends the generic name, *Mucosphaerella*, which had previously been pro-

posed by Johanson. He gives as the correct name of the fungus *Mycosphaerella brassicicola* (Duby) Lindau.

The pycnidial form is a typical *Phyllosticta*, and McAlpine (1901) proposes the new combination *Phyllosticta brassicicola* McAlpine. Cooke (1906) gives *Phyllosticta Brassicae* (Curr.).² But Grove (1914) objects to the above name: "As there is already a *Phyllosticta Brassicae* Westd. having spores of a very different character and a different arrangement of the pycnidia, the present imperfect form will be named *P. brassicicola*." He follows this with a comprehensive description of the new species. He does not state his reasons for disregarding the same combination proposed by McAlpine thirteen years previously.

That the pycnidial and perithecial forms are stages of one and the same fungus has been assumed by all; but actual proof of this fact, beyond that afforded by association, is wanting; nor has the pathogenicity of the

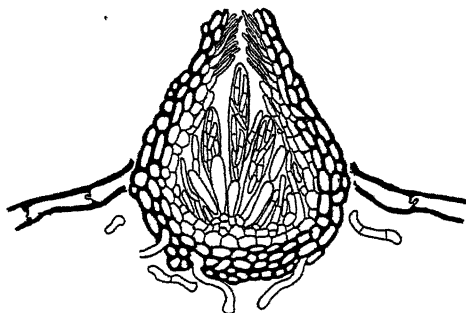


FIG. 2. Longisection of pycnidium of *Mycosphaerella brassicicola*. $\times 330$.

organism been proved so far as the literature shows. When this disease was first brought to the attention of the writers, the possibility of the causal fungus being the same as that which produces "blackleg" was considered. The pycnosporos of the two are identical in size and shape. Specimens of the latter were kindly furnished for comparison by Prof. T. F. Manns, of Delaware, and Dr. L. R. Jones, of Wisconsin. But the two diseases have an entirely different appearance on the plants, and the pycnidia of *Mycosphaerella* are much smaller and of a different shape. The diseases are evidently distinct.

The mycelium grows between and through the cells of the host. It is stout, rather closely septate, much branched, particularly characterized by the presence of numerous large oil drops. It is at first hyaline, but becomes darker with age.

² Currey's description of the fungus has not been seen by the writers.

The pycnidia are produced just beneath the epidermis on either surface of the leaf. The epidermis is ruptured at maturity, but the pycnidia do not project noticeably. They develop symphyogenetically and singly without stromata. In young stages they appear as balls of undifferentiated hyphae. Later, conidiophores of much smaller diameter than the hyphae branch off and fill the center of the mass. Even in mature pycnidia, branches of the large hyphae which made up the original hyphal ball may be seen in the central cavity (fig. 2). The pycnidium is small, generally globose, and dark colored externally on account of the thin outer shell of thick-walled cells. The pycnospores are formed in enormous numbers and ooze out through the ostiole in a pink, gelatinous thread. They are cylindrical, bacilloid, straight or slightly curved, obtuse at the ends, 1.5 to 2.5 by 2.5 to 4.5 μ .

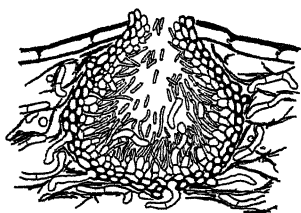


FIG. 3.

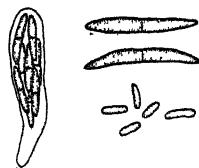


FIG. 4.

FIG. 3. Longisecton of perithecium of *Mycosphaerella brassicicola*. $\times 330$.

FIG. 4. Ascus, ascospores and pycnospores of *Mycosphaerella brassicicola*. The two ascospores and the pycnospores to the right are drawn to the same scale to show comparative size.

In Europe the pycnidial stage is said to be abundant on the green leaves, while the perithecial stage occurs only on the old dying leaves. The perithecial stage is said to be rare there (Grove, 1914), while in Australia it is said to be the commoner of the two. On the material examined here the perithecia are more abundant.

The perithecia also start their development just beneath the epidermis. In the young stage the perithecium is a globose mass of cells which increases rapidly in size and soon breaks through the epidermis. The center becomes filled with a tangle of hyphae composed of short, plump cells which later take on the character of paraphyses. A group of cells on the upper surface grows out to form the neck and the perithecium becomes pyriform. The asci develop in a tuft from the center of the lower part of the core. They do not develop simultaneously, but a few at a time, so that they may be found in various stages of development in the same perithecium. They elongate on maturity (fig. 3). Each ascus contains eight bilocular oblong or somewhat fusiform, hyaline ascospores

(fig. 4) 24.5 by 4.25 μ . The spores are straight or may be slightly curved (fig. 4). The mature perithecium measures about 90 μ broad by 115 μ high, projects from the surface, has a short, conical neck, is dark colored and has a much heavier wall than the pycnidium. At maturity the paraphyses have disappeared and periphyses line the inside of the neck. The perithecia are scattered thickly over the surface of the leaf and several of them may coalesce. No stroma is present.

Control. No control experiments have ever been reported. Kirk (1906) recommends spraying with bordeaux 4-4-50; McAlpine (1901) recommends various sanitary measures, but both admit that they have not tried either. In this country control measures may have to be effected through changes in shipping conditions. The present investigations have not progressed far enough to warrant recommendations.

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SIMPLE TECHNIQUE FOR ISOLATING SINGLE-SPORE STRAINS OF CERTAIN TYPES OF FUNGI

G. W. KEITT .

WITH ONE FIGURE IN THE TEXT

As cultural studies of fungi have become more critical and methods more exact, standard technique has made very general and increasing demands for the isolation of single-spore strains of these organisms. Especially is this necessary in the comparative study of a number of closely related strains or species. In work of this type, the writer was confronted three years ago with the problem of making large numbers of single-spore isolations in limited time. This necessity led to the development of technique by which it was possible under favorable conditions to isolate easily as many as a dozen individual spores within an hour. This method is presented in the hope that it may be useful to others who are engaged in similar work and may thus save some duplication of the time and effort necessary for developing such technique individually. Though details are given it is clearly realized that many variations and modifications may be desirable to meet individual needs and preferences.

The process is merely a convenient and reliable method for executing the old idea of removing from agar plates to suitable substrata blocks of media bearing individual spores, and clearly establishing by subsequent observations that the isolations are free from contamination or admixture.

Media. For work of this type three primary requisites of the medium used are (a) clearness, (b) a suitable consistency, and (c) adaptation to the growth of the fungus to be isolated. While a large variety of substrata may be used with good results, a simple preparation of agar in water, to which a clear nutrient solution may be added, if desirable, at the time of plating, has proved very generally adaptable and satisfactory. The following method of preparation, which is, of course, subject to many minor variations, gives a very clear medium of a suitable consistency:

Dissolve 25 grams of agar (shreds preferred) in one liter of distilled water. Steam for two or three hours, or autoclave at ten pounds pressure for forty-five minutes. Cool to 50°C., add the white of one egg stirred in 100 cc. of distilled water, and mix thoroughly. Steam until a

firm, heavy coagulum is formed. Strain through cheesecloth to remove the bulk of the coagulum, and then through a cotton filter, in an ordinary funnel. The filtrate should be reasonably clear, and should give very good results without further treatment. If a force filter is available, however, the medium may be further clarified by running it through a Büchner funnel in which is placed a mat of macerated filter paper 3 to 5 mm. in thickness. Immediately before use, this apparatus should, of course, be thoroughly washed with hot water to remove all loose particles of filter paper, and to prevent cooling the agar and clogging the filter. Tube and sterilize. Unnecessary severity of sterilization should be avoided.

As a nutrient solution to be added to the agar at the time of plating, a well filtered prune decoction—10 to 50 grams of pitted prune per liter—

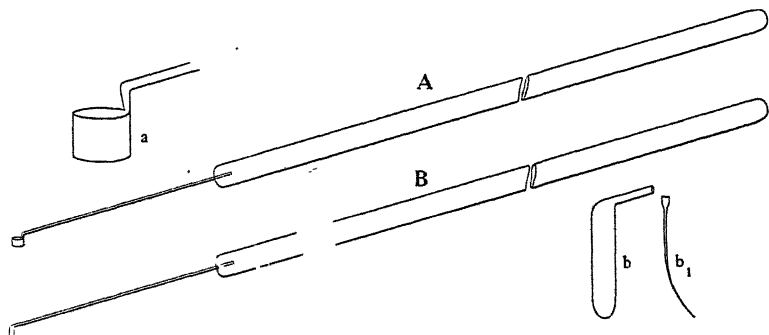


FIG. 1. Devices for the isolation of individual spores from agar plates: A, instrument for cutting cylinder of the medium, $\times \frac{1}{2}$; B, instrument for transferring cylinder, $\times \frac{1}{2}$; a, part of A enlarged; b, part of B enlarged; b₁, end view of b.

has been found generally satisfactory. A great variety of solutions may be used, however, the chief requisites being clearness and adaptation to the growth of the fungus to be isolated.

Special instruments. The only specially prepared apparatus consists of two platinum or platinum-iridium wires worked into the shapes illustrated in figure 1. Their diameter and composition are determined with reference (a) to securing satisfactory rigidity and (b) to providing for as rapid cooling as possible after flaming. The writer has found 22 to 23 gauge wire satisfactory. Platinum-iridium gives better rigidity to the instruments than does platinum, but is harder to work. The hollow cylinder of instrument A is made at such an angle that its lower edge will be parallel to the bottom of the plate when the rod is held in the natural position for use, with the hand resting upon the table. A convenient diameter for the cylinder is 2 mm. It is well, however, to have

several instruments of different sizes. The angle of nearly 90 degrees and the slight lateral curve of the chisel of instrument *B* are found very convenient in picking up the agar discs. The hollow cylinder of *A* and the chisel of *B* should be thin, to facilitate the manipulations and to provide for rapid cooling. With a little practice a crude but efficient set of these instruments may be hammered out in a short time.¹

Method. This work demands only those precautions against contamination which, according to standard technique, should attend the ordinary transfer of pure cultures. When such measures are properly observed, the danger of contamination is practically eliminated.

Pour a dilution series of plates of such nature that one will contain approximately one hundred to three hundred uniformly distributed viable spores, using media of the type above described. For most satisfactory work the depth of the medium in the plate should usually be about 1 mm.

If the spores are too small to be observed easily under the low power of the microscope, incubate the plates until the germ tubes become readily visible, but not long enough for the spores to lose their identity. Working thus with spores in the early stages of germination has the further advantage of providing against the isolation of those which are non-viable.

Study the inverted plates under the low power until the one with the most convenient dilution is determined, and a suitably situated spore is found. Mark the location of the spore carefully by means of an ink dot or a ring on the glass of the petri dish. A mechanical marker attached to the microscope may be used for this purpose, but a skilfully manipulated fountain pen is quite as satisfactory. Make an incision about the spore by means of instrument *A*, inserting it into the petri dish as one would an ordinary needle, and taking the usual precautions to prevent contamination. Invert the plate, and examine under the low power to ascertain whether the spore is uninjured and properly isolated. With instrument *B*, transfer the cylinder of agar bearing the spore to a fresh sterile plate of clear agar (the same medium used for plating is usually satisfactory), and deposit it in a depression previously prepared either by removing a cylinder with the same instruments and precautions used in the above process, or by gouging aside with instrument *B* enough of the medium to allow the transferred cylinder to rest upon the bottom of the petri dish. Note the position of the spore, and ascertain by low power examination whether it is properly isolated and uninjured. If it is necessary for satisfactory observations to use the higher power of the microscope, the transfer may, of course, be made to a van Tieghem cell, instead of a plate.

¹ Specifications for these devices have been given to the Bausch and Lomb Optical Company, from whom the instruments may be procured at a reasonable price.

Observe the development of the spore at intervals sufficiently frequent and numerous to establish beyond doubt that the development is from a single spore and uncontaminated.

Applicability. As used by the writer and a number of others in the laboratory of plant pathology of the University of Wisconsin, this method has proved easily workable, and well adapted to all the organisms tried. It appears to be generally applicable to most fungi which sporulate satisfactorily and germinate and grow on or in agar substrata. It has proved especially useful, further, for the isolation from field material of slow-growing fungi, which, with the ordinary poured plate method, are likely to be overrun by rapidly growing fungi or bacteria.

UNIVERSITY OF WISCONSIN

THE NEED OF A PURE CULTURE SUPPLY LABORATORY FOR PHYTOPATHOLOGY IN AMERICA¹

C. L. SHEAR

The rapid development of phytopathology, the great increase in the number of workers in the field in recent years, and the adoption of more exact and improved methods, are bringing out and emphasizing the desirability of certain aids and improvements in our facilities for investigation. The particular matter to which I wish to call attention at this time is that of providing more adequate means for the collection, cultivation, distribution, and permanent preservation of pathogenic organisms and their relatives.

The relative importance of artificial cultures of pathogenic organisms, and fungi in general, has increased very rapidly in recent years and will undoubtedly continue to increase in the future. Recent investigations also indicate that more and more dependence must be placed upon the cultural characters and behavior of organisms in determining their identity and pathological relations. Formerly, reliance was placed chiefly or entirely on morphological characters in identifying fungi. As our knowledge derived from cultural studies and inoculation experiments increases we find that organisms may possess distinctive physiological characteristics not always accompanied by distinguishable morphological differences under natural conditions. Such organisms can, however, frequently be distinguished by cultural characters under artificial conditions or by inoculation experiments.

The unsatisfactory character of even the best descriptions as a means of positive identification of microscopic organisms has undoubtedly been at one time or another realized by most pathologists. This is particularly true in case of cultures even with the most exact and complete descriptions. The positive identification of an organism in culture is in many cases impossible without an authentic culture for comparison, and is in all cases greatly facilitated by such a culture. It would seem hardly necessary to attempt any detailed argument to prove the great desirability and value of a convenient source of supply of authentic or accurately identified pure cultures of the various organisms with which plant patholo-

¹Read at the special meeting of the American Phytopathological Society, Berkeley, Cal., August 5, 1915.

gists may be working. The great saving in time and labor which would result if investigators were able at any time to obtain a pure culture, authentic or identified with certainty, of organisms which they were studying, but of whose identity they were not entirely certain, would be ample return for the cost of establishing and maintaining a means of supplying such cultures. Of far greater importance, however, would be the increased accuracy and reliability of the results of pathological and mycological studies. There is probably no active worker in plant pathology who has not at some time felt the need of authentic cultures for comparison with his own. This need has been met in some cases by individual exchanges of cultures. As you probably know, an attempt has already been made in Europe to meet this longfelt want. The Association Internationale des Botanistes undertook this work some years ago and placed it under the immediate direction of Dr. Johanna Westerdijk, the pathologist of the "Willie Commelin Scholten" of Amsterdam. This work is carried on under the title of "Centralstelle für Pilzkulturen." Miss Westerdijk has been very successful in her work and has supplied many cultures to American pathologists. Unfortunately, limitations in funds and assistants prevent her from meeting the great demands and requirements of the pathologists of the world as a whole. The great distances which separate the pathologists of America from the laboratory at Amsterdam make it almost impossible to satisfactorily supply us from that source. To meet the requirements of American pathologists it seems necessary to establish a supply laboratory in this country. Such a laboratory could and should work in active and hearty cooperation with the Centralstelle in Amsterdam and the two laboratories should be of great mutual assistance. Another supply station might very properly be established in Japan. The facilities needed in America are a central supply laboratory which shall make a special effort to secure by collection, purchase or exchange, and maintain for distribution, pure cultures of the various pathogenic organisms and their relatives which are obtainable from the different laboratories and workers, not only in this country but throughout the world. At the same time type cultures or authentic cultures should be permanently preserved by the most suitable method in each case, for purposes of future study and comparison. Sub-cultures from the type or authentic cultures should be made, renewed from time to time, and kept in sufficient quantity to meet the requirements of pathologists. One of the first requirements for the successful maintenance of such a laboratory would be the most active and generous support of pathologists and mycologists in furnishing such cultures as they may possess. Each worker should send to the central laboratory cultures and specimens of any new organisms he may discover or any authentic or

interesting cultures of other organisms. In this way there would be accumulated a large and important collection of specimens and cultures of inestimable value for the present and future.

It is not our purpose to attempt to give a detailed plan of just how such a supply laboratory should be handled, or where, or under what auspices it should be managed. Since the great bulk of the pathological work in America is carried on by the United States Department of Agriculture and the state agricultural college and experiment stations, it would seem natural that such an undertaking should be chiefly controlled by these agencies.

Our purpose in calling attention to the matter at present is to arouse discussion and initiate some action which may lead to the establishment of such a laboratory in this country in the near future. As a step in this direction I would suggest that the Society appoint a committee to consider the subject and make such recommendations as it deems desirable.

BUREAU OF PLANT INDUSTRY

WASHINGTON, D. C.

NOTES ON SOME NORTH AMERICAN RUSTS WITH CAEOMA-LIKE SORI

C. A. LUDWIG

All the genera of North American rusts having caeomoid sori at any stage in the life history have been treated in one or the other of the two rust numbers of the North American Flora which have already been published. Since the publication of these numbers, however, several facts of interest have become known concerning some of these rusts, especially in the genera *Coleosporium* and *Melampsora*. In order to record these new facts the writer has made a study, at the suggestion of Dr. J. C. Arthur, of all the North American caeoma-forms of rusts; and the present paper embodies the most valuable new data secured in the study.

The term "caeoma-like" as used in this study has reference to the form of the sorus, rather than to function or accompanying structure, and is applicable to a sorus which has no surrounding structure limiting it or preventing true coalescence, and which has the spores borne in chains. A sorus surrounded by paraphyses, as in the aecia of *Phragmidium* and *Earlea*, which are often called caeomoid, is not therefore a caeoma-like sorus in the present sense, because the paraphyses persist even in case of apparent coalescence and separate the sori from each other. The rusts which are included as having caeoma-like sori are as follows: uredinia in *Coleosporium*, twenty-five species; aecia in *Melampsora* and undistributed *Caeoma*, eleven species; aecia in *Neoravenelia*, one species; telia in *Gymnoconia*, two species; aecia in *Eriosporangium* (in part), five species. Other species of *Eriosporangium* are not included because fragile peridia are present or the aecia are unknown. The following key will serve to distinguish the different groups.

KEY TO THE GROUPS OF RUSTS WITH CAEOMA-LIKE SORI

- Sori not accompanied by pycnia..... Group I, *Coleosporium*
- Sori normally accompanied by pycnia
 - Spore walls finely verrucose; spores broad
 - Sori from a limited mycelium
 - Fungus not causing notable hypertrophy;
sori yellow to white..... Group II, *Melampsora*, etc.¹

¹ Unconnected species of *Caeoma*, such as *C. conigenum* and *C. strobilinum*.

Fungus causing conspicuous hypertrophies; sori densely crowded on these areas, reddish brown	Group III, <i>Neoravenelia</i>
Sori from a diffused mycelium	Group IV, <i>Gymnoconia</i>
Spore walls rather coarsely verrucose; spores usually long and narrowed at one or both ends . . .	Group V, <i>Eriosporangium</i>

No new material of much importance was secured concerning the last three of the groups of rusts just mentioned, and they will not be given further treatment. The first two in the list, however, deserve further discussion.

GROUP I. COLEOSPORIUM

Group I includes the uredinia of the genus *Coleosporium*. The rusts of this genus have all four of the spore forms in the life cycle and are heteroecious. The pycnia and aecia occur as species of the form genus *Peridermium* on pine leaves. The uredinia and telia occur on various broad-leaved plants. For a long time the greatest taxonomic problem in connection with this genus in North America has been to match up the large number of recognized species of *Coleosporium* with the far fewer species of *Peridermium*. One of the possibilities is that not all the species of *Peridermium* have yet been described. The likelihood of this is especially great in Mexico and Central America, regions which are as yet very imperfectly explored botanically. There is another possibility, however, which amounts almost to a demonstrated fact; and this is that several of the species as now accepted are not true species in a restricted sense of the term, but are identical with one another except for host specialization, and may be considered more properly as biological races. An important experimental contribution to this belief is some recently published culture work by Klebahn.²

In this work Klebahn shows that *Schizanthus Grahami*, a solanaceous plant from South America, is susceptible to the following European species of *Coleosporium* when inoculated with urediniospores: *C. Euphrasiae* on *Alectorolophus*, *C. Melampyri* on *Melampyrum*, *C. Campanulae* on several species of *Campanula*, *C. Tussilaginis* on *Tussilago*, and *C. Senecionis* on *Senecio*. The last three species were also able to infect *Tropeolum minus*. As a conclusion from these results, it is clear that in the genus *Coleosporium*, as in many others, the presence of bridging hosts shows the very close relationship or practical identity of some forms now considered distinct species. Such being the case, further cross inoculation work of this nature must inevitably reduce very considerably the number of recognized species of this genus. The work on the genus

² Zeitschr. Pflanzenkr. 24: 14—20. 1914.

Tubercles of uredinospores broader.....	<i>C. Dahliae</i>
Tubercles of uredinospores more cylindrical	
Uredinospores comparatively large, 19 to 24 x	
26 to 37 μ and teliospores comparatively small,	
10 to 13 x 26 to 33 μ	<i>C. Plumierae</i>
Uredinospores smaller, 20 to 24 x 20 to 28 μ , and	
teliospores larger, 14 to 20 x 24 to 45 μ	<i>C. Mentzeliae</i>

(*Coleosporium Bletiae* Dietel, which was collected once in California, is now undoubtedly absent from North America, and so is not included in this list.)

The rust on *Campanula* and that on *Senecio*, both of which have been collected in America (although the latter only once) are included in the report by Klebahn mentioned above, and are therefore combined here, the name being *Coleosporium Campanulae* (Pers.) Lév. No other combinations are made, although the following probable identities are suggested from the morphological studies:

(I) *C. Viburni* and *C. arnicale*. These two forms are usually separated on the basis of the character of the spore wall markings, the first being comparatively coarse and rough and the second finer and more even. Aside from the fact that they inhabit different hosts the difference just mentioned is about all that can be made out, and this difference is little if any greater than one would expect to be induced by the different hosts. If the two should prove to be identical, as suggested, the name for both would be *Coleosporium Viburni* Arth.

(II) *C. Ipomoeae*, *C. Solidaginis*, and *C. Laciniariae*. These three forms are very much alike, both as to uredinia and as to telia. The urediniospores are evenly and very finely verrucose, especially in the case of the first two. The markings in the case of *C. Laciniariae* are a bit coarser and rougher, approaching in this respect the species in the next group. Indeed, it is possible that the two groups should be combined, but the differences are great enough to make it seem unlikely that they should be so disposed. Should these three forms prove to be identical, the proper name would be *Coleosporium Ipomoeae* (Schw.) Burrill.

(III) *C. Helianthi* and *C. anceps*. The evidence for considering these two forms as separate species lies in a slight difference in shape and spore surface of the urediniospores. The spores of the former are more generally globoid in shape and have more slender papillae. In all other characters they seem to agree well, and they occur on the same host genus, so that it seems very likely that they are to be considered identical. The name, in case of identity, should be *Coleosporium Helianthi* (Schw.) Arth.

(IV) *C. Elephantopodis* and *C. Eupatorii*. These two forms are suggested to belong together on the basis of a close resemblance of the uredi-

niospores only. They are much alike in size, shape, wall thickness, and wall markings. It has not been possible to compare teliospores, however, as none are known as yet for *C. Eupatorii*. The name, should they prove to be identical, will be *Coleosporium Elephantopodis* (Schw.) Thüm.

The three groups just discussed (II, III, and IV) differ from one another chiefly in the character of spore wall markings, and the variation from one to the other is so gradual as to make it very difficult to decide where to draw the line between groups. It is not altogether improbable, therefore, that when culture work shall have settled the question definitely the grouping of these forms will be somewhat different from that given above.

(V) *C. Campanulae* and *C. occidentale*. *C. occidentale* is a western form on Senecio which exhibits some differences from the European form on Senecio. The fungus as a whole has a more robust character than is found in the European form. The urediniospores are larger, the walls a little thicker, and the markings are coarser. Aside from these things it agrees very well with the other. Only one collection of the western form is at hand, and it is possible that it is an exception in this respect. At any rate, the difference is such as would be induced by a robust, coarse habit in the host. Should they prove to be identical, the name *Coleosporium Campanulae* (Pers.) Lév. should be used.

If this set of suggestions as to identities should prove correct, the number of North American species of *Coleosporium* would be reduced from twenty-five to nineteen, a number which approaches somewhat more nearly the number to be expected, but which seems even yet too large, as according to Arthur and Kern,³ there are in North America eleven recognized foliicolous species of *Peridermium* on pine. The difference of eight species will probably be accounted for by the discovery of other telial combinations not yet suggested, or by the discovery of more undescribed species of *Peridermium*, or by both means. Cross inoculation work with urediniospores is very important in this group.

GROUP II. MELAMPSORA AND CAEOMA

Group II includes the aecia of the genus *Melampsora* and in addition a number of undistributed aecia of the same general character occurring on Pinaceae. The genus *Melampsora* is characterized by having a full life-cycle, of which the aecia are caeomoid and the telia waxy, with single-celled teliospores compacted into a layer. The pycnia are either subcuticular or subepidermal. The last three species included in the group are quite different in some characters from the others and probably have

³ *Mycologia* 6: 109—138. 1914.

some other telial connection than *Melampsora*. Eleven American species are recognized, one on Grossulariaceae, one on Saxifragaceae, and the rest on Pinaceae.

The following key will serve for the identification of species in this group:

Key to the Species of Melampsora and Caeoma

- Pycnia subcuticular, wholly above the epidermis
 - Spores globoid to ellipsoid
 - Pycnia hemispherical
 - Sporophyte occurring on Salix..... *M. Bigelowii*
 - Sporophyte occurring on Populus..... *M. Medusae*
 - Pycnia disk-shaped to conical..... *M. Abietis-canadensis*
 - Spores broadly ellipsoid..... *M. albertensis*
- Pycnia subcuticular, when mature located just above the mesophyll tissue and occupying the place of a number of disintegrated epidermal cells..... *M. arctica*
- Pycnia subepidermal
 - Spores ellipsoid to globoid
 - Wall moderately thin, 1.5 to 2.5 μ *M. confluens*
 - Wall thicker, 2 to 3 μ *M. alpina*
 - Spores globoid
 - Wall thin, uniform..... *M. Lini*
 - Wall thicker, thickened at apex..... *C. dubium*
- Pycnia subcorticular
 - Bubakia* (?) group, including..... { *C. conigenum*
C. strobilinum

The following species of this group are of interest for one reason or another and deserve further consideration:

(I) *Melampsora Bigelowii* Thüm., with sporophytic stage on Salix, and *M. Medusae* Thüm., with the same stage on Populus, are two species both of which have pycnia and aecia on leaves of Larix. These latter sori are so nearly alike that it is impossible with our present knowledge to tell them apart by morphological characters. There seems to be no chance, however, that they are merely races of the same species because there are very evident structural differences in the urediniospores. The urediniospores of *M. Medusae* are larger than those of the other, usually longer for their thickness, are flattened on two opposite sides in a very large percentage of the spores, and have the wall thickened on the flattened sides; while the urediniospores of *M. Bigelowii* are regular in shape and have walls of uniform thickness.

(II) Another species of interest in this connection is the one on *Tsuga canadensis* connected by Fraser⁴ with uredinia and telia on Populus. This species is herewith discussed somewhat in detail.

⁴ *Mycologia* 4: 188. 1912. *Ibid.* 5: 238. 1913.

Melampsora Abietis-canadensis (Farl.) n. comb.

Caeoma Abietis-canadensis Farl. Proc. Am. Acad. **20**: 323. 1885.

Peridermium fructigenum Arth. Bull. Torrey Club **37**: 578. 1910.

Caeoma Tsugae Spaulding, Sci. n. s. **33**: 194. Hyponym. 1911.

ON PINACEAE:

Tsuga canadensis (L.) Carr. (*Abies canadensis* Michx.), Chebacco Lake, Massachusetts, June, 1883, A. B. Seymour; Nova Scotia (W. P. Fraser, Pictou, June 30, 1911 and July 18, 1912, Truro, July 10, 1910); Quebec (Fraser, Hudson, 1913); Wisconsin (J. J. Davis, Ellison Bay, July 14, 1913, Mellen, July 14, 1908, Fish Creek, July 5, 1913); Connecticut (Perley Spaulding, East Granby, June 21, 1908, 114, Granby, June 26, 1909, 2060). The collection issued as Barth. Fungi Columb. 3103 and N. Am. Ured. 103, and said to be *Caeoma Abietis-canadensis* on *Tsuga heterophylla* is *C. dubium*, and therefore does not belong here.

DISTRIBUTION: Connecticut to Nova Scotia and westward to northern Wisconsin.

EXSICCATI: Ell. & Ev. Fungi Columb. 1882.

The type collection (the first one mentioned above), which is on leaves, was issued as no. 1882 of the second series of Ellis & Everhart's N. Am. Fungi, where it is credited to Dr. W. G. Farlow, who communicated the material to the publishers. Part of the type is in the Arthur herbarium.

The first *Tsuga* rust on cones brought to the notice of the workers in this laboratory was the East Granby collection by Spaulding. In the examination of this material some structures were found which were interpreted as peridial cells and the species was published as *Peridermium fructigenum*. Later, Spaulding published the same species as *Caeoma Tsugae*, without, however, giving a description. Since then two such collections by Fraser have been received, one of which he had connected by field evidence with *Melampsora* on *Populus*, and the other of which was a culture from teliospores on *Populus*. A study of these four collections shows that they are the same species, and are caeomoid in character. The cells which were interpreted as peridial cells might well be large abnormal spores.

The aecia and telia of this rust occur on *Populus*, and were formerly included in *Melampsora Medusae*. The writer has studied Fraser's collections in comparison with the wealth of material in the Arthur herbarium referred to *M. Medusae*. This study has shown that the species is distinct from *M. Medusae*, and can be recognized in the uredinal stage by the morphological characters of the spores. The spores are small, 13 to 18 by 16 to 24 μ (about the size of the smallest ones in *M. Medusae*), and uniformly and broadly obovoid to globoid, as contrasted with an abundance of long narrow spores in the other species. The wall is uniform in thickness or only slightly thickened laterally, whereas in *M.*

Medusae the wall is regularly flattened and much thickened on two opposite sides. The following hosts and localities are here given for the uredinal and telial stage:

ON SALICACEAE:

Populus candicans Ait., Connecticut, Massachusetts, Michigan; *P. deltoides* Marsh., Indiana; *P. grandidentata* Michx., Connecticut, Indiana, Michigan, Ohio, Nova Scotia; *P. heterophylla* L., Indiana; *P. Sargentii* Dode, Iowa; *P. tremuloides* Michx., Indiana, Maine, Ohio, Tennessee, Ontario.

EXSICCATI: Kellerm. Ohio Fungi 144, 145; Barth. N. Am. Ured. 111.

(III) *Melampsora arctica* Rostr. has aecia on *Abies balsamea* (L.) Mill. and *A. concolor* Lindl., with a distribution from Nova Scotia and New Hampshire westward to and extending southward in the Rockies. The aeciospores on *Abies concolor* are somewhat coarser in character than those on *Abies balsamea*; i.e., they have thicker cell walls and coarser markings on the walls and are somewhat larger than the others. However, there seems to be no doubt that the two forms are the same species, although the rust has not yet been cultured on *A. concolor*, because the variation mentioned is the kind which such host differences usually induce in a rust, and because they both exhibit the same peculiar kind of pycnia as here described. The pycnia are subcuticular, but instead of being situated on top of the epidermal cells, as is usual with subcuticular pycnia, they are situated in a cavity in the epidermis caused by the complete disintegration of a number of cells. Because of this habit they are very easily interpreted as being subepidermal.

(IV) Another interesting and apparently undescribed rust is one on *Tsuga heterophylla* from the northwest. It has been impossible with the dried specimens at hand to determine whether the spores are catenulate or pedicellate. They are borne at a definite distance from the hymenium as if pedicellate, and it has been impossible to demonstrate any chains, even of immature spores. On the other hand it has been equally impossible to demonstrate the presence of pedicels, and it is easy to see how the appearance described might be produced by a sorus of catenulate spores in which the apical spore of each chain matures and becomes detached before the next one enlarges appreciably. Furthermore, the sori are accompanied by pycnia, showing that they function as aecia; and the spore walls are verrucose, indicating the catenulate arrangement. The writer does not know of any rust having spores functioning as aeciospores which are both verrucose and pedicellate. It is, therefore, with a fair degree of confidence that this species is classed with *Caeoma* instead of with *Uredo*, although more material is necessary in order to determine the point definitely.

On account of the subepidermal pycnia this species is rather easily distinguished from *Melampsora Abietis-canadensis* and *Uredo Holwayi* on the same host, both of which have subcuticular pycnia. *U. Holwayi* is distinguishable further by having echinulate spore walls and by having the sorus surrounded by a pseudoperidium of paraphyses. The alternate stage of the undescribed species is likely some *Melampsora*-like rust from the northwest which is perhaps not yet described. It is not likely a genuine *Melampsora*, however, as all of the species of *Melampsora* known to have aecia on Pinaceae are characterized by subcuticular pycnia, whereas this has subepidermal pycnia.

A description is here appended:

***Caeoma dubium* n. sp.**

O. Pycnia hypophyllous, rather numerous, scattered, noticeable, subepidermal, golden brown, hemispherical to disk shaped, 80 to 115 μ wide by 50 to 80 μ high; ostiolar filaments absent.

I. Aecia hypophyllous in two longitudinal lines, subepidermal, oblong, 0.2 to 0.4 mm. wide by 0.3 to 0.8 mm. long, not crowded, pulverulent, light yellow when dry, early naked, ruptured epidermis evident; aeciospores broadly ellipsoid to globose, 15 to 21 by 15 to 22 μ ; wall colorless, 1.5 to 2.5 μ thick, often thickened above, 3 to 4.5 μ , prominently and very closely verrucose.

ON PINACEAE:

Tsuga heterophylla (Raf.) Sarg., Bainbridge Island, Kitsap Co., Washington, July 17, 1909, *E. Bartholomew 4087*, type (in Barth. N. Am. Ured. 103, Fungi Columb. 3103); Grizzly Creek Trail, Beaver River Valley, British Columbia, July 27, 1907, *E. W. D. Holway*.

DISTRIBUTION: Northwestern United States and western Canada.

(V) *Caeoma conigenum* Pat. and *C. strobilinum* Arth. are two forms which are very similar to each other and may ultimately be found to be identical. *C. strobilinum* was originally separated from the other on the basis of having much thinner and less verrucose spore walls. A reexamination of spores from the type material of both does reveal that, in general, the spore walls of *C. conigenum* are the thicker and more coarsely verrucose of the two, but that many spores in the type of *C. strobilinum* nearly or quite equal them in these respects. In size and shape of spores and in distribution of markings they are practically identical. However, the material of *C. conigenum* at hand is only fragmentary, so that a careful comparison of other characters could not be made. Because of this, therefore, and because the most likely alternate stage, *Bubakia* on *Croton*, is represented by two species, one of which is in the region of *C. conigenum* and the other in the region of *C. strobilinum*, the writer considers that it is not wise at this time to combine the two.

PHYTOPATHOLOGICAL NOTES

Sugar beet curly-top. The writer has read with much interest the article entitled "New Light on Curly-Top of the Sugar Beet," on page 103 of the April number of PHYTOPATHOLOGY. The point that appears new to Messrs. Smith and Bonequet is the finding of lesions containing bacteria in the diseased beets, though inoculations with pure cultures of these bacteria gave negative results. Miss Nellie A. Brown, of the Pathological Laboratory, Bureau of Plant Industry, and myself have frequently observed the lesions or pockets containing bacteria and have repeatedly isolated an organism from curly-top beets, but, like the authors of the article mentioned, we have not been able to reproduce the symptoms by inoculation with artificial cultures. Until this is done, we can hardly say that we have any new light on the subject, but rather that we have a "lead" that may eventually throw some light upon the real cause of curly-top. It seems to me decidedly misleading to herald as "new light" any discovery of this kind until we know and can demonstrate that it has or has not some direct relation to the disease under investigation.

So far as has been determined *Eutettix tenella* appears to be the only carrier of the disease-producing agent, and yet there seem to be conditions under which this insect may appear to infest the beet plant without producing curly-top, even though the external conditions surrounding the plant seem to be favorable for the development of the disease. Are the beets sometimes resistant to the disease-producing agent or is *Eutettix tenella* sometimes free from the exciting agent? There are also "leads" that may help us to solve the problem, but until we can reproduce the disease at will we must remain in the dark as to its real cause. Furthermore, until we know the real cause of curly-top there can be but faint hope of solving the more important economic problem of its control.

C. O. TOWNSEND

Florida plant board. The legislature of the State of Florida has created a Plant Board, which now has the same personnel as the Board of Control of the State Institutions for Higher Learning, charged with the control of plant diseases and insect pests. For the ensuing biennium there is appropriated the sum of \$125,000 for the campaign against citrus canker and \$70,000 for other pests. Prof. Wilmon Newell, formerly entomologist at the Texas Experiment Station, has been appointed Plant Commissioner,

Mr. E. W. Berger, entomologist, Dr. R. A. Jehle, formerly of the Cuban Experiment Station, plant pathologist, and Mr. F. M. O'Byrne, Inspector of Nurseries.

Personals. Dr. Howard S. Reed, formerly head of the Department of Plant Pathology and Bacteriology in the Virginia Polytechnic Institute and Plant Pathologist in the Virginia Agricultural Experiment Station, removed to Riverside, California, on July 1, to accept a position as Plant Pathologist and Bacteriologist of the Citrus Experiment Station at that point. He is succeeded by Dr. F. D. Fromme, formerly Assistant in Botany in the Indiana Agricultural Experiment Station.

Prof. H. S. Jackson, formerly Botanist and Plant Pathologist of the Oregon Agricultural Experiment Station, Corvallis, Oregon, assumed his duties on September 1 as Chief in Botany at the Agricultural Experiment Station of Purdue University, La Fayette, Indiana. Dr. J. C. Arthur, who was head of this Department, has retired under the Carnegie Foundation for the Advancement of Teaching.

Mr. Paul A. Murphy, formerly of the Department of Agriculture and Technical Instruction for Ireland and more lately engaged in post-graduate work in the Department of Plant Pathology of Cornell University, has been appointed as Assistant Pathologist in the Division of Botany of the Department of Agriculture of Canada and will be stationed at the Experimental Farm at Charlottetown, Prince Edward Island. Mr. G. C. Cunningham, formerly Assistant Plant Pathologist at the Vermont Agricultural Experiment Station, has accepted a similar position with headquarters at Fredericton, New Brunswick.

Dr. F. Kølpin Ravn of the Danish Royal Landbohjskolens, arrived at New York on May 6, having made the trip from Denmark on the Danish-American ship Helig Olaf. On the seventh of May he delivered an address at Rutgers College, New Brunswick, New Jersey. He then visited successively Massachusetts Agricultural College, Amherst, Massachusetts; Pennsylvania State Agricultural College, State College, Pennsylvania; Cornell University, Ithaca, New York; Purdue University, La Fayette, Indiana; Wisconsin University, Madison, Wisconsin; University of Nebraska, Lincoln, Nebraska; and Kansas Agricultural College, Manhattan, Kansas. At each of these different colleges one or more of the following lectures were delivered:

- (1) The development of plant pathology and modern agricultural progress in Denmark.
- (2) Heredity and plant diseases.
- (3) On the possibility of determining losses in cereals due to fungous diseases.

(4) The possibilities of indemnification for the loss caused by diseases transmitted through seed.

The last lecture was delivered at Manhattan, Kansas, on the twenty-second of May.

Following that date Doctor Ravn visited the United States and state experiment stations at Tucson and Yuma, Arizona; Berkeley and Medford, California; Corvallis and Moro, Oregon; Bellingham, Spokane, and Pullman, Washington; Bozeman, Montana; Aberdeen, Idaho; Brigham and Logan, Utah; Fort Collins, Greeley, and Akron, Colorado; Madison, Wisconsin; Minneapolis, Minnesota; Fargo, North Dakota; and Brookings, South Dakota. He also visited Indian reservations in Arizona and many private farms and grain fields along the route, and attended the Interstate Cereal Conferences at Berkeley, Davis, and Chico, California, from June 2 to 4 inclusive, returning to Washington on July 18.

An informal reception was tendered Doctor Ravn on Monday evening, July 19, by Mr. M. A. Carleton, of the Bureau of Plant Industry, and on Thursday evening, July 22, the Botanical Society of Washington gave a dinner in his honor at the Cosmos Club in Washington. While on his western trip Doctor Ravn discovered the yellow leaf rust of wheat (*Puccinia glumarum* Eriks. and Henn.) in a field near Sacaton, Arizona. On August 9 to 11 inclusive he participated in a three days' collecting trip at Ithaca, New York, and on August 16 to 18 he visited Aroostook County, Maine, where he participated in a conference on potato diseases held at the field laboratory of the Bureau of Plant Industry, at Presque Isle. He sailed from New York for the West Indies on August 19 and after a sojourn of two weeks returned to Copenhagen by way of New York.

Dr. Otto Appel sailed from New York for Bergen, en route to Germany, on August 14, and arrived safely at his destination.

LITERATURE ON AMERICAN PLANT DISEASES¹

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June-July, 1915

Appel, Otto. Leaf roll diseases of the potato. *Phytopathology* 5, no. 3: 139-148. June, 1915.

Published also in *Rpt. Iowa State Hort. Soc.* 49 (1914): 203-211. 1915.

Arthur, Joseph Charles. Uredinales of Porto Rico based on collections by F. L. Stevens. *Mycologia* 7, no. 4: 168-196. July, 1915.

Ashby, S. F. Coconut diseases in Jamaica. *Jour. Jamaica Agr. Soc.* 19, no. 5: 165-168. May, 1915.

Bud rot, leaf diseases, root disease, dwindling or pencil-point, stem disease.

Babcock, D. C. A new scarlet oak disease. *Phytopathology* 5, no. 3: 197. June, 1915.

Botryodiplodia sp.

Baker, Carl Fuller. A review of some Philippine plant diseases. *Phil. Agr. and Forester* 3, no. 7: 157-164. 1914.

Barrett, J. T. Some observations on wither-tip in 1914. *Proc. 45th Fruit Growers' Conv. California* 1914: 242-244. 1915.

Colletotrichum gloeosporioides.

Discussion, p. 243-244.

Baun, R. W. de. Some common potato diseases. To be seen at blooming time. *Rural New Yorker* 74, no. 4314: 889-890. July 10, 1915.

Bondar, Gregorio. *Heterodera radicicola* . . . sobre o parasitismo do "Heterodera radicicola" nos cafeeiros. *Bol. Agr. [São Paulo]* 16, no. 4: 329-330. Abril, 1915.

Brown, Theodore. Potatoes without blight. *Proc. New Jersey State Hort. Soc.* 40th Ann. Sess. 1914: 53-57. 1915.

Discussion, p. 55-57.

Byrce, P. I. Apple leaf-spot or black rot canker. 7th Ann. Rpt. Quebec Soc. Prot. Plants 1914/15: 86-90, 3 fig. 1915.

Sphaeropsis malorum.

California. Laws, Statutes, etc. Uniform horticultural laws. *Mo. Bul. State Com. Hort. [California]* 4, no. 7: 318-320. July, 1915.

An act . . . in relation to the establishment of quarantine against infectious plant diseases; State quarantine order.

Carter, C. N. A powdery mildew on citrus. *Phytopathology* 5, no. 3: 193-196, 1 fig., pl. 12. June, 1915.

Oidium tingitaninum sp. nov.

¹ This list aims to include the publications of North and South America, the West India Islands, and islands controlled by the United States, and articles by American writers appearing in foreign journals.

All authors are urged to cooperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agric., Washington, D. C.

- Coe, H. S. Apple blight. 11th Ann. Rpt. South Dakota State Hort. Soc. **1914**: 184. 1914.
Bacillus amylovorus.
- Apple scab. 11th Ann. Rpt. South Dakota State Hort. Soc. **1914**: 10-11. 1914.
Venturia pomi.
- Black rot of apples. 11th Ann. Rpt. South Dakota State Hort. Soc. **1914**: 95-96. 1914.
Sphaeropsis malorum.
- Plum pockets. 11th Ann. Rpt. South Dakota State Hort. Soc. **1914**: 94-95. 1914.
Exoascus pruni.
- Potato scab. 11th Ann. Rpt. South Dakota State Hort. Soc. **1914**: 35-36. 1914.
Oospora scabies.
- Compere, George. Blight-resistant pear stocks. Mo. Bul. State Com. Hort. [California] **4**, no. 7: 313-314, fig. 67-68. July, 1915.
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- Cook, Melville Thurston. Common diseases of apples, pears and quinces. New Jersey Agr. Expt. Sta. Circ. **44**, 20 p., 18 fig. [1915].
- Common diseases of the peach, plum and cherry. New Jersey Agr. Expt. Sta. Circ. **45**, 16 p., 10 fig. [1915.]
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- Coulter, John Merle. Charles E. Bessey. Science n. s. **41**, no. 1060: 599-600. April 23, 1915.
- Day, Leonard H. Apricot gummosis and sour sap—report on observations and inoculation experiments, Mo. Bul. State Com. Hort. [California] **4**, no. 7: 330-332. July, 1915.
 "Several distinct parasitic diseases in which gummosis is the first externally evident symptom, are commonly classed as sour sap."
- Dodge, Bernard Ogilvie. Relationship between *Roestelia transformans* and *R. botryapites*. Torreya **15**, no. 6: 133-134. June, 1915.
- Edson, Howard Austin. *Rheosporangium aphanidermatus*, a new genus and species of fungus parasitic on sugar beets and radishes. Jour. Agr. Research **4**, no. 4: 279-292, pl. 44-48. July, 1915.
- Ellett, Walter Beall, and Grissom, J. T. The amount of arsenic in solution when lead arsenate is added to different spray solutions. Virginia Agr. Expt. Sta. Ann. Rpt. **1913/14**: 160-164. 1915.
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- Elston, Leo Weiss. The resistance of varieties of fruits to injurious insects and diseases. Proc. New Jersey State Hort. Soc. 39th Ann. Sess. **1913**: 189-191. 1914.
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REPORT OF SPECIAL MEETING OF THE AMERICAN PHYTO-
PATHOLOGICAL SOCIETY AND THE PACIFIC DIVISION,
UNIVERSITY OF CALIFORNIA, BERKELEY, CALIFORNIA,
AUGUST 3 AND 5, 1915

Addresses of welcome were delivered by Dr. Herbert J. Webber, Director of the Citrus Experiment Station and Dean of the Graduate School of Tropical Agriculture, Riverside, California, and by Professor R. E. Smith, President of the Pacific Division of the Society.

Dr. Haven Metcalf responded for the society.

The sessions were presided over by Dr. Haven Metcalf, in the absence of the President and Vice-President of the American Phytopathological Society, and Professor R. E. Smith, President of the Western branch; by Professor R. E. Smith, and by Professor H. S. Jackson, newly elected President of the Western branch, respectively. The attendance at the three sessions varied from forty to fifty persons.

The following programme was presented:

International phytopathology. OTTO APPEL, *Dahlem, near Berlin, Germany.*

Read by Dr. C. L. Shear, to be published in full in PHYTOPATHOLOGY.

Pythiacystis infection of deciduous nursery stock. E. H. SMITH, *University of California, Berkeley.*

"A die-back of young deciduous trees, which occurred extensively in northern California the past two seasons, has been traced to a species of *Pythiacystis*, morphologically identical with *P. citrophthora*. Most of the root stock is apparently immune, but above the bud the bark is infected causing one to several cankers, which often girdle the tree and kill back the whole top. Profuse gumming occurs. The fungus has been isolated from peach, almond, pear and plum, and the disease produced by inoculation in apple, pear, peach, almond, apricot, prune and cherry, all from one-year-old stock. Similar cankers have been produced by inoculation with *P. citrophthora* isolated from lemon fruit. A Pythiaceous fungus has been twice isolated from almond cankers, and successfully inoculated into almond, which readily develops an oosporic stage. This has different characters of growth from the original strain, and a less degree of pathogenicity, but may ultimately prove to be the same species."

Two eastern forest diseases which threaten the Pacific States. With lantern. HAVEN METCALF, *U. S. Department of Agriculture, Washington, D. C.*

The speaker exhibited lantern slides and specimens of the chestnut bark disease (*Endothia parasitica*) and the white pine blister rust (*Cronartium ribicola*). The danger which these diseases present to the cultivated chestnut of the Pacific States, and to the native stand of five-leaf pines, was indicated. Especially to be considered is the danger to the very valuable species, *Pinus lambertiana* and *P. monticola*. The speaker advocated rigid state quarantines against nursery stock of the genus *Castanea*, the five-leaf species of pines, and the genus *Ribes*.

Beet blight. R. E. SMITH, *University of California, Berkeley, Cal.*

Specimens of diseased beets were exhibited and the methods being employed in the study of the disease were explained and illustrated. The structure of the dis-

eased beets was discussed and certain peculiarities were described. Possible connection with certain bacteria was suggested and the nature and difficulties of the problem concerned were discussed. In the discussion which followed the paper, Director Ball of Utah and a number of other persons gave their views on certain phases of the problem, especially with regard to the relation of the disease to insects. Mr. August Bonquet of Spreckels, California, gave support to the suggestion that only insects which have been in contact with diseased beets are capable of transmitting the disease.

Forest pathology. E. P. MEINECKE, *U. S. Department of Agriculture, San Francisco.*

A number of forest diseases were exhibited including interesting and important rusts and mistletoes. A number of new hosts were shown in the collection and important, but hitherto not well-known forms were included in the demonstration.

Northwestern apple anthracnose. H. S. JACKSON, *Corvallis, Oregon.*

Materials were shown of the disease in various forms and the technical phases, particularly cultural work and cross-inoculations with the different spore forms were discussed as well as the economic status of the disease.

Apple mildew. W. S. BALLARD, *U. S. Department of Agriculture, Watsonville, Cal.*

The nature of apple mildew was explained briefly and some account of the history of the efforts which have been made to discover effective control measures was given. Use of colloidal sulphur, prepared by dissolving sulphur in melted rosin, grinding and putting into ammonia water and diluting, was described. The difficulties involved in the use of sulphur in the California coast districts on account of the danger of injury to the trees were discussed and the reasons for the use of unusually dilute spray formulas were described.

Mottled leaf of citrus. J. T. BARRETT, *Riverside, Cal.*

Professor Barrett reviewed the main features of the disease and showed typical specimens. No specific cause has been discovered and the disease is still classed as a physiological disease. The diseased leaves contain more starch than normally on account of defective translocation and apparently also an excess of nitrogen. Some relation appears to have been discovered between fertilization with nitrate of soda without the addition of vegetable material and mottled leaf, but it was pointed out that this is probably not a direct effect of the materials used but of the soil condition produced, since in plots in which liberal use had been made of vegetable material, the disease has not appeared. The disease is being studied at Riverside from all possible points of view and is being treated as a Station problem and not exclusively by any one department. The possibility of an infectious chlorosis is also being investigated. In the discussion Professor F. S. Earle pointed out that there are probably two distinct types of mottled leaf in Cuba and the Isle of Pines, arising from what is probably a specific disease of the small roots and from general unfavorable soil conditions.

Bacterial canker of cherry and filbert disease. H. P. BARSS, *Corvallis, Ore.*

Griffin has already shown the bacterial origin of the bud blight in cherries. The identity of cause for bud blight and body canker was shown by the speaker by means of inoculations made in the fall. Inoculations at other seasons were not successful. The disease is most destructive during the first seven or eight years of the life of the tree. It is now largely controlled by planting Mazzard stock and grafting in the limbs of this. Natural cankers have been found in apricot, prune and Simoni plum.

The filbert disease is also caused by bacteria. The organism in this case is yellow and similar to the walnut blight bacterium. A leaf spotting and killing of twigs is produced and cankers are formed, succulent tissue being susceptible.

Crown-rot of fruit trees: Histological studies. J. G. GROSSENBACHER, U. S. Department of Agriculture, Washington, D. C.

Read by title.

Some new and old methods in plant pathology. J. FRANKLIN COLLINS, U. S. Department of Agriculture, Washington, D. C.

Read by title.

Citrus gummosis and melaxuma. H. S. FAWCETT, Whittier, Cal.

These diseases were illustrated by means of lantern slides and brief explanations together with a set of specimens and photographic enlargements. Gummosis is caused by the fungus *Pythiacystis citrophthora* S. and S. and melaxuma by a fungus probably of the genus *Dothiorella*.

Fruit stain and wither-tip of citrus. J. T. BARRETT, Riverside, Cal.

Effects of the fungus, *Colletotrichum gloeosporioides*, were illustrated on twigs and fruit. Dr. Barrett stated that he did not yet have evidence that the fungus is capable of infecting thoroughly sound and healthy tissue of leaves and twigs but infection of the fruit through germination from appressoria, killing small areas of rind, and later development of the fungus cause serious fruit rotting in addition to the tear-stain marks upon the surface.

Observations on prune rust, Puccinia pruni-spinosae Pers., in Southern California.

J. T. BARRETT, Riverside, Cal.

The disease caused by *Puccinia pruni-spinosae* has become serious at times in Southern California in apricots and peaches. The characteristic spots and injury to the orchard by defoliation were shown by lantern slides. In some cases, early fall pruning has stimulated fall growth in which foliage remains alive through the winter and rust developed in this has permitted early spring infection with very detrimental effect to the orchards.

Coryneum fruit spot of apricot. J. T. BARRETT, Riverside, Cal.

Characteristic spotting was shown with lantern slides. Fruit spot has been confused with other troubles by growers and is not of so universal distribution in apricots as has been supposed. Accordingly, spraying operations have not given satisfaction in all cases.

Walnut blight and crown gall. C. O. SMITH, Whittier, Cal.

The symptoms of this disease were illustrated by means of lantern slides and specimens were shown in the laboratory.

Peridermium harknessii Moore and *Cronartium quercuum* (Berk.). E. P. MEINECKE, U. S. Department of Agriculture, San Francisco, Cal.

The results of extensive observations on these rusts and inoculation experiments with the different spore forms were given.

An established Asiatic Gymnosporangium in Oregon. H. S. JACKSON, Corvallis, Oregon.

Results of careful studies and cross-inoculations with a newly imported Japanese *Gymnosporangium* discovered on oriental pears in Oregon were given.

The need of a pure culture supply laboratory for plant pathology in America. C. L. SHEAR, U. S. Department of Agriculture, Washington, D. C.

Published in full in this issue of PHYTOPATHOLOGY.

Studies of the Rhizoctonia disease of potatoes. J. H. CORSAUT, Corvallis, Oregon.

On account of the seriousness of potato troubles due to *Rhizoctonia* in the state of Oregon, studies on this disease were undertaken. Affected plants and tubers were

secured from different localities and a large number of different strains of the causal organism were isolated from sclerotia on the tubers, from sterile mycelium on the underground parts of the plant, from basidium-bearing mycelium and from individual basidiospores. The cultural characters of these strains were similar but showed some variation. A splendid development of the typical Corticium (*Hypochmus*) stage appeared on the stems of young plants grown in sterilized soils from sterilized seed pieces which had been inoculated with pure culture of the organisms isolated from sclerotia, sterile mycelium and single basidiospores. A number of different varieties of potatoes were inoculated with *Rhizoctonia*, grown under similar conditions and the effects noted. Some varieties proved extremely susceptible while others were rather strongly resistant. It was also found that when grown on sterile raw plugs cut from different varieties of potatoes the fungus developed rapidly on certain varieties and but slowly on others. By artificial means, healthy, *Rhizoctonia*-free potato plants were made to reproduce both the *aerial potato* condition and the *little potato* condition which are frequent consequences of natural attacks of *Rhizoctonia*. These experiments indicate that the abnormal effects referred to are purely secondary results of the *Rhizoctonia* attack caused by interference with the normal process of food storage in the plant.

Studies of Monilia blight of fruit trees. G. B. POSEY, *Corvallis, Oregon.*

Read by H. P. Barss. Very interesting results of cultures and inoculations with a large number of strains, including three distinct forms of *Monilia* in Oregon, were presented.

A Podosporiella disease of germinating wheat. P. J. O'GARA, *Salt Lake City, Utah.*

"On examining a weak strand of wheat in Salt Lake Valley the trouble was traced back to the seed, the content of the kernels of which were found to have been largely consumed by a dark brown, septate mycelium, which did not appear on the surface. The seed coat was penetrated later by the fruiting stalks of the fungus, which was found to be a new species of *Podosporiella*. The fungus is not considered to be a true parasite, since it does not attack the kernel until about the time of germination, and has never been found in the growing portions of the plant. The disease is found to be most prevalent in volunteer wheat, and where several crops have been grown with only surface cultivation.

The utilization of certain pentoses and compounds of pentoses by Glomerella cingulata.

L. A. HAWKINS, *U. S. Department of Agriculture, Washington, D. C.*

In the experiments an attempt was made to determine the effect of the apple bitter rot fungus upon the pentose containing compounds of the apple fruit, the relative value of certain pentoses and compounds of pentoses as sources of carbon for this fungus and the effect of an aqueous extract of the fungus mycelium upon xylan. It was found that the fungus increased the alcohol soluble pentosan content of the apple fruit but decreased the total pentosan content. The fungus readily utilized either xylose, arabinose, xylan or arabin as sources of carbon. The two pentoses were more favorable sources of carbon than glucose. Aqueous extracts of the fungus mycelium when allowed to act on xylan produced xylose. It is evident that the fungus secretes an enzyme which hydrolyzes xylan to xylose.

Armillaria or oak fungus disease in California. W. T. HORNE, *University of California, Berkeley, Cal.*

Cultures and specimens were exhibited and the action of the fungus briefly described. There was considerable discussion of this important disease by a number of those present.

Wednesday, August 4, was spent with the botanists at Stanford University, and the plant pathologists joined the biologists in a dinner in San Francisco in the evening.

Following the reading of Doctor Shear's paper, upon motion, the chairman was directed to appoint a committee for the purpose of considering the question of the establishment of a culture supply laboratory. The committee appointed was C. L. Shear, chairman, and L. R. Jones, with power to select a third member.

In the intermission between the second and third sessions, a business meeting of the Pacific Division was held, in which a report was made by the secretary-treasurer as to the activities of the division and its financial condition. Officers for the ensuing year were elected as follows: H. S. Jackson, president; J. T. Barrett, vice-president; W. T. Horne, secretary-treasurer.

The matter of affiliation with the Pacific Division of the American Association for the Advancement of Science was reported on and the matter of the next meeting was left until the next meeting of that society should be decided. The question of relation to the parent society was then taken up and the report of a joint committee was adopted so that affiliation will be accomplished when the report has been adopted by the parent society. The adoption of this report changes the name of the local society to the American Phytopathological Society, Pacific Division, and also establishes the distinction originally made between associate and active members, active members being those who are also members of the parent society.

C. L. SHEAR

Secretary-Treasurer

WM. T. HORNE

*Secretary-Treasurer,
Western Division*

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THE GROUPING AND TERMINOLOGY OF PLANT DISEASES

LEO E. MELCHERS

Considerable interest has recently been shown by plant pathologists concerning the classification of plant diseases, and the necessity and possibilities for further research in the so-called physiological plant disease group. Smith¹ has recently shown that our knowledge relative to physiological diseases in general is inadequate and that the necessity for more thorough research in this group of diseases is imperative. This has been further emphasized by Grossenbacher,² who clearly demonstrates the necessity of investigational work in certain neglected phases of phytopathology, namely, the development and maturation of abnormal plant tissues, particularly with reference to the effects of environment. The vagueness of the term physiological plant diseases, the indefinite knowledge regarding their causes, and the practical significance of the lack of the element nitrogen in plant nutrition, as the possible cause of some physiological diseases, is forcibly stated by Lipman.³

It appears to the writer that certain facts relative to the meaning of the term physiological plant diseases have been overlooked, and furthermore, the scope and number of plant diseases occurring in this group have become more complex as time has elapsed, without proper readjustments. It is not with a didactic attitude, nor the thought of criticism, that the writer offers the following suggestions; he assumes the rôle of an interested student in phytopathology, dealing with facts as they appear, and not that of a connoisseur of the subject.

Since the writer became interested in plant disease investigations, his understanding and interpretation of the use and meaning of the expres-

¹ Smith, R. E. The investigation of physiological plant diseases. *Phytopath.* 5: 83-93. 1915.

² Grossenbacher, J. G. Some neglected phases of phytopathology. *Phytopath.* 5: 155-162. 1915.

³ Lipman, Chas. B. A suggestion of a new phase of the problem of physiological diseases of plants. *Phytopath.* 5: 111-116. 1915.

sion, "physiological disease," have been as vague and indefinite as the term has been loosely used. It has been easier for plant pathologists to place a plant malady in the physiological disease category, than to conclusively demonstrate by means of histology, parasitology, cytology or biochemical investigations that it belongs in a more definite group. Furthermore, it is unfortunate that plant pathologists have been employing the term, physiological disease, to include a group of non-parasitic diseases. In order to reach a better understanding, and with the idea in mind that some of the suggestions herein contained may be of help in arriving at some definite conclusions, the writer is attempting to present his views on the professional use of the term, physiological plant disease.

The following suggestions and statements are made with two fundamental ideas in mind. First, the term physiological plant disease, as employed by the plant pathologist, lacks scientific meaning. Within the profession its present use is possibly understood, and so far as this is concerned, its immediate requirements may be met. We are attempting, however, to assign to this term a meaning which, from a scientific viewpoint, is fundamentally misleading.

Second, we are not lucid or explicit in the separation of the various kinds or groups of diseases into (1) physiological diseases, (2) those of undetermined origin, and (3) fungous and bacterial diseases. It is the writer's purpose, in part, to show that what is regarded in some cases as a physiological disease should more properly be placed in the undetermined group, while others should be placed in a group which is etiologically unrelated to pathogenic organisms.

To go back to the first criticism, namely, of the use and meaning of the term physiological diseases; this expression is apparently a favorite among plant pathologists. Heretofore, when an investigator has been at a loss as to the etiology of a plant trouble, it has been branded a physiological disease. How many have actually analyzed the meaning of this expression? It is obvious that the term thus used indicates little correlation of scientific facts. Plant physiology deals with the functioning of a plant, regardless of whether that plant belongs to the phylum Schizophyta, Mycophyta, or Anthophyta. The very fact of a plant's developing and growing in intimate relationship with another plant, symbiotically, parasitically, or otherwise, involves the further fact that it carries on those vital, inherent, physiological processes peculiar to itself, independently of the associated plant. The two are separated individuals and their capacity to exist depends upon their independent, internal activities. The benefit or injury which one of these plants may derive from, or impose upon the other is entirely a different problem, involving, besides physiological phenomena, the most intimate and intricate relations between them. In

both, physiological phenomena play their independent, inevitable rôle, the importance of which can readily be understood.

This might be further exemplified by considering group 3, i.e., plant diseases of fungous or bacterial origin, as compared with other diseases. Plants affected by maladies belonging to this group likewise have their vital functions interfered with. It matters little, however, whether it is a direct case of malnutrition, or not; the host ceases to function normally, but in this instance the abnormal condition is known to be caused by the inroads and advances of one plant form over the other, producing unbalanced physiological phenomena in the host. It is obvious that all plant diseases belonging to this group involve physiological disturbances, and it must be just as evident that the various inherent, physiological phenomena produced by the host and by the pathogene are carried on independently of each other. Therefore, it appears that this group contains plant diseases which are just as definitely physiological in nature as are those of group 1.

The ultimate causes of many of the physiological diseases are unknown or undetermined, a fact which has already been brought out; but since there is a physiological disturbance, as in all plant abnormalities, regardless of their cause, the matter is dismissed for the time and the name "physiological disease" is given. What this conveys in pathological terms and what it actually expresses leads to some confusion, or at least shows it to be a misnomer—for in truth all plant diseases are physiological phenomena. According to the writer's conception, this expression conveys the idea of a disease having specific symptoms, not known to be produced by pathogenic organisms as far as investigations show; its cause may be known, or it may be undetermined, possibly inherent or self-induced, abnormal, and interfering with the normal functioning of the host. For example, the so-called enzymic disturbances, such as peach yellows, little peach and the mosaic disease of solanaceous plants; the straight head of rice and oat blast (thrips?); such maladies as exanthema, bitter pit of apples, lightning injury, leaf scorch, and sun scald; such troubles as leaf roll of potato, chlorosis, oedema, blossom-end-rot of tomato and brachysm in cotton—all these have been arbitrarily placed in this one group. The list could be greatly enlarged, but examples are so familiar to plant pathologists that it is unnecessary to further enumerate.

Since it has been the writer's intention, in part, to show that the term, physiological disease, is not a desirable name for this group of ailments, it might be advisable to offer a substitute. It would appear as though the term, non-parasitic diseases, would be more appropriate—a term which is employed by European investigators, but which seems to have been avoided or overlooked by plant pathologists in this country.

The second point which the writer desires to make is, that the types of disease generally included in the physiological group are too varied in nature to be classed all together. It would seem desirable that some of these should be placed among those plant maladies, the real cause of which is undetermined. These would include those types which can be produced at will by one of the methods of artificial inoculation or infection, in which tissues or juices of diseased plants are employed, such as the mosaic disease, peach yellows, curly-top of sugar beet, and so forth.

A certain analogy can be drawn between the undetermined group and the Deuteromycetae, or Fungi Imperfecti. The Deuteromycetae are placed in the scheme of classification under the Mycophyta, and between the Ascomycetae and Basidiomycetae, because of the possibility of revealing a phylogenetic relationship to a Basidiomycete instead of an Ascomycete. The undetermined group of diseases might be considered in a similar manner. Is it not possible that this group may disclose plant diseases of a mycological, bacteriological, or possibly some day, of an ultra-microscopic nature? This has been found to be the case with gummosis of cherry and lemon, and western tomato blight, at one time considered physiological diseases. If diseases of a doubtful nature are kept in the undetermined group until more thorough studies have been completed, and investigations conclusively confirmed, it would be possible properly to classify them. Until then it becomes necessary to have a tentative but at least not incorrect grouping.

The question arises whether there are not still others in the group of physiological diseases which are of undetermined origin. Certain maladies in this group, which are brought about by something possibly inherent, self-induced and pathogenic, cannot be produced at will as, for example, the hereditary trouble in cotton known as brachysm, chlorosis in plants, potato leaf roll, oedema in plants and perhaps the blossom-end-rot of tomato. Such diseases are to be considered non-parasitic, and are as it were, autogenous in nature. They should perhaps be separated from all others and given a sub-group name. That such a class of *autopathogenic* diseases—if we might coin the term—may be of greater importance than generally considered is to be interpreted from the recent article by Grossenbacher.

It appears to the writer that in this country plant disease investigations have been somewhat too narrowly limited to the mycological aspect of phytopathology. A study of the host is too frequently slighted if not neglected. Adequate emphasis has not been placed on the intricate problems involving non-parasitic diseases, and furthermore, it would seem that pathological conditions produced by animal parasites should not be omitted from the plant pathologists' field of research. Do not the sci-

ences of human and veterinary pathology include all pathological conditions of animals? Can an entomologist, zoologist or "plant pathologist" be a competent diagnostician with but a partial knowledge of the diseases of plants?

The accompanying diagram will aid in an understanding of the following recapitulation:

	GROUP 1	GROUP 2	GROUP 3 ⁴
CURRENT CLASSIFICATION	PHYSIOLOGICAL DISEASES	DISEASES OF UNKNOWN ORIGIN	FUNGOUS AND BACTERIAL DISEASES
SUGGESTED CLASSIFICATION	NON-PARASITIC DISEASES Exanthema Bitter pit Lightning injury Leaf scorch Sun scalds etc. <i>(Autopathogenic diseases)</i> Leaf roll of potato Chlorosis Oedema Blossom-end-rot of tomato Brachysm in cotton etc.	DISEASES OF UNKNOWN ORIGIN Mosaic disease Peach yellows Little peach Curly-top of beets Straight head of rice Oat blast (thrips?) etc.	PARASITIC DISEASES All diseases caused by fungous or bacterial organisms

The groups as they now stand in their current classification, together with suggested changes, are:

Group 1 comprises in the current classification, all the diseases listed under groups 1 and 2 of the suggested classification, i.e., such diseases as peach yellows, little peach, mosaic disease, curly-top of beets, maladies which are transmissible and may be due to some undiscovered ultra-microscopic organism; straight head of rice and oat blast; such non-parasitic diseases as exanthema, leaf scorch, lightning injury, sun scald and bitter pit of apples, which are anatomico-physiological derangements; and such ailments as, leaf roll of potato, chlorosis, oedema, blossom-end-rot of tomato and brachysm in cotton, which may be more or less self-induced, inheritable in some cases, and unquestionably pathological in nature.

⁴ If maladies due to insect and other animal parasites are to be included, logically they would be placed in this group.

Group 2 contains plant diseases of undetermined origin.

Group 3 contains plant diseases of fungous or bacterial origin.

According to the writer's ideas the following arrangement may be offered as a suggestion.

Group 1 should be renamed non-parasitic diseases, with the possible sub-group as already suggested; namely *autopathogenic* diseases. This main group should contain only plant diseases which are definitely known to be of non-parasitic nature, and all others heretofore classified in the physiological group, should be placed at the discretion of the Society in group 2, or the undetermined group.

For the rest, group 2 and group 3 should remain as they now stand. The suggested change in the name of group 3 from fungous and bacterial diseases to parasitic diseases is thought advisable.

KANSAS STATE AGRICULTURAL COLLEGE

MANHATTAN, KANSAS

AN ANTHRACNOSE-RESISTANT RED KIDNEY BEAN

MORTIER F. BARRUS

WITH FOUR FIGURES IN THE TEXT

Since 1910, the writer has been working on the resistance and susceptibility shown by varieties of the common bean (*Phaseolus vulgaris*) to anthracnose, caused by the fungus *Colletotrichum lindemuthianum*. Four years ago it was shown¹ that varieties of beans showing resistance to one strain of the pathogene may be susceptible to another strain of the same pathogene; that is to say, "there is a distinct difference between cultures of anthracnose obtained from diverse sources, in their power to infect the various varieties of beans." At the same time it was stated that "the writer has not found any varieties of *Phaseolus vulgaris* that have been resistant to every strain of the bean anthracnose fungus tested."

At the present time there are a few varieties that have shown considerable resistance to anthracnose but none are more promising than a strain of Red Kidney which has been under observation for three seasons. It has shown thus far a high degree of resistance to anthracnose when inoculated with the fungus under artificial conditions, as well as when grown in the field under natural conditions favorable to the extensive development of the disease and when, indeed, the common strain of Red Kidney became so badly infected as to be practically worthless.

The attention of the writer was first called to this strain in 1913 by Mr. John Q. Wells of Shortsville, New York, who had been searching for some clean Red Kidney seed in order to test the clean seed method of controlling anthracnose. This strain secured by Mr. Wells was originally selected by Mr. Byron Luce of Marion, New York, eleven or twelve years ago. Mr. Luce found a single plant standing up alone, the only healthy one in the field. Several years passed before Mr. Luce and his brothers had enough seed to plant their own fields. Mr. Luce sold his interest in the farm and his nephew and a few neighbors are now growing this strain. They have made no effort to disseminate it, so that now not more than fifty acres are grown in that section this year. In 1912 these beans were said to pick² but two pounds out of a bushel while common

¹ Barrus, Mortier F. Variation of varieties of beans in their susceptibility to anthracnose. *Phytopath.* 1: 190-195. Pl. XXIX. 1911.

² "Picking" a certain number of pounds is a term used commonly by farmers and buyers to mean the number of pounds of poor beans picked out of a bushel. In the case mentioned the large pick was due mostly to the large number of spotted seed.

Red Kidney's grown beside them, planted at the same time, and treated alike, picked thirty pounds.

Mr. Wells sent the writer some of this seed which he called a blight resistant strain and wished to have it tested for resistance. It was then included in the variety tests for resistance to anthracnose. The first inoculation of this strain was made August 3, 1913 on seedlings grown in the greenhouse with strain F of *Colletotrichum lindemuthianum*. An examination on August 17, showed results recorded as follows: Of 19 plants inoculated, 4 showed fair³ infection, 14 slight, and 1 no infection. Susceptible varieties inoculated at the same time under similar conditions gave good to excellent infection. No plants of the common strain of Red Kidney were inoculated at this time but previous inoculations had shown it to be susceptible to this strain of the pathogene. Subsequent inoculations with this and other strains of the organism made on seedlings grown in the greenhouse about the age of the potted plants shown in figure 1 are given in the following tables. The results secured from inoculations made at the same time on the ordinary strain of Red Kidney or on other varieties are included for comparison. For convenience the resistant strain has been designated Wells' Red Kidney.

For the purpose of obtaining illustrations the resistant and common strain of Red Kidney were grown in the same pot, inoculated at the same time with various strains of the pathogene, and after infection had shown up well, one pot, showing results secured from each strain represented, was photographed. An explanation of the results secured will be found in the explanation of the several figures. In each case the plants of the resistant strain became but slightly or not at all infected while those of the common strain were destroyed.

In order to ascertain whether Red Kidney beans in other localities might show resistance, seed was obtained in 1915 from seedsmen in Boston and Marblehead, Massachusetts, Bristol and Philadelphia, Pennsylvania, Chicago, Illinois, New York City, and points in Yates, Ontario, Monroe, and Seneca counties, New York. Four samples of the resistant strain were obtained from different localities. Two plantings were made in the greenhouse and one in the garden, and inoculated with a mixture of strains

³ Degrees of infection expressed as follows:

Excellent—Plant destroyed.

Good—Abundant lesions. Plant does not die but is so badly affected that it could not produce a crop.

Fair—Several lesions well defined, but plant enabled to live and produce a fair crop.

Slight—Few lesions, but apparently not affecting growth of plant.

Very slight—Very small, scarcely distinguishable lesions present.

None—No lesions observed on any part of plant.

TABLE I

Showing results secured on varieties of beans from inoculations with cultures of *Collectotrichum lindemuthianum* under conditions favorable for infection

STRAIN OF PATHOGENE	DATE OF INOCULATION	DATE OF INSPECTION	VARIETY	NUMBER INOCULATED	NUMBER INFECTED	DEGREE OF INFECTION ³
A	Dec. 7, 1913	Dec. 22, 1913	Currie Rust Proof	13	13	Excellent.
			Wells' Red Kidney	7	2	2 slight, 5 none.
			Round Six Weeks	13	13	Excellent.
			Kentucky Wonder			
			Wax	10	10	Excellent.
			White Prolific	14	14	Excellent.
B	Dec. 20, 1913	Dec. 28, 1913	Hodson Wax	18	18	Excellent.
			Common Red Kidney	14	14	8 fair to good, 6 affected at base of stem only.
			Wells' Red Kidney	15	2	2 slight, 13 none.
						Later there were indications of lesions but nothing appeared that would injure the plant.
			Childs' Horticultural	17	17	Excellent.
Mixture of A & N	Jan. 16, 1915		Detroit	8	8	Good.
			Wells' Red Kidney	8	8	Slight.
			Rust Proof Intermediate Horticultural	9	9	Good.

A, F, K, and N of *Collectotrichum lindemuthianum*. In tables II and III are shown the results secured from these inoculations.

The vines of Wells' Red Kidney stood up well and, in the garden, produced well-filled clean pods in comparison with the others which did not need artificial inoculation as early in August they were badly infested.

This resistant Red Kidney seems to be a distinct strain. Not enough careful notes have been taken to give a description of the difference in the appearance of the vines between this strain and the common one, but there is a recognizable distinction. The seeds are a lighter red color and have a clean bright appearance in bulk. Some dealers have expressed themselves as believing this lighter color to be detrimental to their sale while others say that it is not.

TABLE II

Showing results secured in greenhouse on seedlings of two plantings of Red Kidney beans, inoculated with strains A, F, K, and N of *Colletotrichum lindemuthianum*

VARIETY	NUMBER OF PLANTS IN-OCULATED	NUMBER OF PLANTS INFECTED	DEGREE OF INFECTION				
Wells' Red Kidney from 4 localities ..	60	30		5 good	5 fair	20 slight or very slight	30 none
	59	59	5 excel-lent	8 good	34 fair	12 slight or very slight	
Common Red Kidney from 10 localities.	117	115	98 excel-lent	15 good	1 fair	1 slight	2 none
	140	138	43 excel-lent	71 good	18 fair	6 slight	2 none

TABLE III

Showing results obtained in pods and seeds from growing Red Kidney beans, secured from various sources, in disease garden, where they were exposed to natural infection and in addition the resistant strain was inoculated on August 21, 1915 with a mixture of strains A, F, K, and N of *Colletotrichum lindemuthianum* under conditions favorable for infection.

STRAIN	NUMBER OF PLANTS	NUMBER OF PODS PRODUCED	NUMBER OF PODS INFECTED	DEGREE OF INFECTION	GRAMS OF SEED	
					Good	Cull
Wells' Red Kidney from four localities.	109	901	73 ¹	Slight to fair	1748	132
Common Red Kidney from nine localities.	223	1121	1093 ²	Good to excellent	593	339

¹ These pods came from 15 plants.

² The 28 anthracnose-free pods came from 3 plants.

In the fall of 1913, the writer visited Mr. Wells who wished him to observe the difference in appearance between the resistant and the common strain growing in adjoining fields on his farm. The common strain was very badly infested and the pick from it must have been considerable, but a careful examination of the resistant strain showed a remarkable freedom from the disease. Since then Mr. Wells has been growing only the resistant strain. What seed he had for sale was sold to farmers in Ontario, Yates, Monroe, Orleans, Wyoming, Seneca, and Tompkins counties, New York. He estimated that at least two hundred acres of beans from this seed had been grown this year, and that the yield should be at least four thousand bushels. Most of this stock will not go, on the general market, but will be saved for seed purposes.

An opportunity was given the writer to examine many of these fields and the beans were found in every case to stand up well and to be comparatively free from anthracnose. It is true that now and then an infected plant could be found, but the loss was practically nothing. Several fields were planted in part to Wells' Red Kidney and the remainder to the common strain. Even early in August the two strains in such fields could be distinguished at a distance because vines of the resistant strain covered the ground while those of the other strain were already so badly affected that they did not nearly occupy the ground. In fact, the planting of the resistant kind or of the ordinary kind meant the difference, this year, between a profitable and an unprofitable crop.

The season of 1915 has been exceptionally favorable for the development of most parasitic fungi and bean anthracnose has been epiphytotic throughout the state especially on the variety Red Kidney. It has been, therefore, a very satisfactory year to test, under natural field conditions, the resistance of this strain of Red Kidney to this disease. It has fully come up to the highest expectations of those who are interested in it. It may be true that some strain of the anthracnose fungus not yet used for inoculation, may be able to bring about an infection. But as long as it can be grown and remain as free from anthracnose as it has been in the past, it is the most satisfactory Red Kidney bean to grow. It should be tested in other sections where this variety is commonly grown.

Badly affected plants among the resistant ones probably represent impurities in the seed for no great amount of effort has been made in the past to keep them pure. Crosses may have taken place between these beans and the common kind growing in adjoining rows. An effort is being made by a few farmers who are growing no other kind of bean than this strain to eliminate mixtures or any plants showing susceptibility to anthracnose by roguing the field carefully. As an additional precaution it may be advisable to select the most desirable plants in the field for planting a seed plot to be maintained each year.

Wells' Red Kidney is not resistant to bacterial blight caused by *Bacterium Phaseoli*, to brown rot caused by *Sclerotinia libertiana*, or to the root rots common in some parts of New York. Bacterial blight is seldom a serious disease here. The brown rot occurs only during exceptionally wet seasons on beans whose vines cover the ground and even then does comparatively little damage. The root rots are very troublesome in some localities and as yet little is known regarding their control. Anthracnose has been responsible for the enormous loss to beans this year, but it is hoped that the new strain will enable growers of Red Kidney beans to avoid further loss from this disease.

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Fig. 1. 88a, Wells' Red Kidney. 88, common Red Kidney planted in same pot in greenhouse, inoculated March 2, 1915, with strain A of *Colletotrichum lindemuthianum* under conditions favorable for infection. Photograph made March 12. This strain of the organism has never procured infection on common Red Kidney.



Fig. 2. 88a and 88 planted in the same pot in greenhouse, inoculated March 2, 1915, with strain F of *Colletotrichum lindemuthianum*, and photographed March 12.

On 88, excellent infection occurred. One plant of 88a showed fair infection and an occasional lesion could be found on the others.



Fig. 3. 88a and 88 planted in same pot in greenhouse, inoculated March 2, 1915 with strain K of *Colletotrichum lindemuthianum*. Photograph made March 14. 88 showed excellent infection while 88a showed only slight lesions on the three plants.



Fig. 4. 88 and 88a planted in same pot in greenhouse, inoculated April 3, 1915, with a mixture of strains A, F, and K, of *Colletotrichum lindemuthianum*. Photograph made April 12. 88 showed excellent infection while 88a showed 1 with fair, 1 with slight, and 2 with no infection.

FIRE BLIGHT ON CHERRIES

J. W. H O T S O N

WITH PLATE XIV

During 1914 and 1915 a great deal of damage was done to the orchards of the Yakima Valley by fire blight caused by *Bacillus amylovorus*. This disease has been known in the Valley since 1905 and probably existed here some time before that date but, partly through ignorance of the character of the disease and partly through a fear of depreciating the value of property, the presence of fire blight was kept quiet for about seven years. During these years the disease gradually became more and more prevalent, finally becoming so thoroughly established that it required drastic methods even to hold it in check. Although the apples and pears were the principal trees affected, yet not infrequently it was found on the quince, prune, crab, and Yakimine.

During the spring and early summer of 1915 there was a noticeable increase in the number of fruit infections. Frequently a number of infected pears or apples might be found on trees where there was very little twig or body infection present. About the middle of June when the cherries were beginning to ripen the writer's attention was drawn to a peculiar condition of the fruit on Royal Ann cherry trees near Selah, Washington. On examination two trees were found to be affected, one a large tree about eight or ten years old and well loaded with fruit. The other, which was located close to the former, was a small three-years-old Royal Ann with only a few cherries on it. At the time these trees were first examined by the writer about one-third of the fruit on the larger tree was affected.

The cherry disease first appears as small depressions in the surface of the fruit. These are usually few in number at first but eventually occur practically all over the surface, gradually decreasing the size of the cherry and giving it a shrunken, wilted appearance. In figure 1 of Plate XIV is shown a branch with affected fruits and a few cherries not diseased. The relative size of the diseased and sound cherries as well as the general wilted, wrinkled condition of the former may also be seen in this figure. This same condition is illustrated also in figures 2 and 3, the former being only slightly affected while the latter represents a more advanced stage of the disease. In some instances, as shown in figures 4 and 5, small

amber-colored, sticky beads are produced, resembling very strongly the exudation of fire blight. As far as has been observed this trouble is confined entirely to the fruit, giving no evidence of disease on the twigs or leaves.

In order to determine definitely and conclusively whether or not this exudate was the result of *Bacillus amylovorus* a number of careful experiments were carried on. A preliminary examination with the compound microscope showed abundance of bacilli resembling this organism.

In making the gross cultures on pears the following method was adopted: White granite dishes eight inches in diameter and two and one-half inches deep were washed, sterilized in corrosive sublimate (1 to 1000) and then rinsed in sterile water. Panes of glass (10 inches by 12 inches), which were used as covers, and the green pears, on which tests were made, were treated in a similar way. Care was also taken to select pears for these experiments from trees not infected with fire blight. These precautions were taken in order to eliminate as far as possible all chances of contamination. The pears after being treated were cut in half with a sterilized knife and three or four halves were placed in each granite dish with sufficient sterile water to cover the bottom but not enough to reach to the cut surface of the pears. One half-pear in each dish was always left as a control, the others were inoculated from the beads of exudate occurring on the fruit of the cherry, each dish then being covered with a pane of glass. All of these inoculations produced the characteristic milk-white beads such as are found when the fire blight organism is treated in a similar way. In figure 8 of Plate XIV is shown the result of an inoculation directly from the exudate on the cherry to sterilized pears. Gross cultures were also made from the flesh taken just beneath the skin of wilted cherries which were apparently affected but did not show any exudate. Many of these did not produce the blight organism although some did. The organisms thus obtained on the sterilized pears were inoculated into the young, rapidly growing shoots of a Bartlett pear. This tree is shown in figure 6 with the two twig infections at *a* and *b*. The former which is a typical terminal infection of fire blight is reproduced on a larger scale in figure 7. The stems and leaves have turned black showing the characteristic scorched appearance.

From the gross cultures on pears inoculations were also made on the fruit and twigs of Royal Ann and Bing cherries while still attached to the tree. In some instances the fruit was punctured with a fine needle while in others the organism was smeared over the surface of the cherry. The infected fruit was protected from the direct sunlight by cloths. Four days after inoculation the punctured cherries began to show evidence of infection. They became depressed and began to dry in the region of

inoculation. In seven days small beads of exudate began to appear over the surface of the fruit. This exudate was inoculated into pear twigs and also upon sterilized pears as already described. In both these cases the typical fire blight reaction was obtained.

In order to more clearly demonstrate that the organism producing this "cherry blight" is identical with that producing fire blight, exudate was taken from an infected cherry and inoculated directly into the twig of a pear tree and also on Bing and Royal Ann cherries. The results were the same as those previously obtained. A large number of gross cultures of the fruit of cherries was also made in the laboratory. These were arranged with the same care and precaution as in the case of the pears. In the majority of these cases typical exudate was obtained but as time went on only ripe cherries could be obtained for experimentation and these would either crack and become contaminated in the moist chambers or begin to decay before results could be obtained. Of the cherries inoculated while still on the tree over ninety per cent. showed unmistakable evidence of fire blight infection.

The organism producing this disease was also plated out in the usual manner and pure cultures obtained both from the exudate found on the original infected fruit and also from the flesh just beneath the skin. Both of these cultures produced the characteristic reaction of fire blight when inoculated on the sterilized cut pears in the laboratory and pear twigs in the field.

One other experiment was tried in connection with this disease. The organism of fire blight obtained from the exudate from apple and pear trees was inoculated into the Royal Ann and Bing cherries. A majority of these cases where punctures were made proved successful.

In general, artificial infections were readily produced whenever the fruit was punctured. As many as half a dozen or more depressions, each probably representing a point of infection, were found on single cherries. It is highly improbable that all of these inoculations could be made at punctures. In some cases minute punctures have been observed but in the large majority of instances no evidence of a wound could be seen. The cherry season has been too short to determine definitely by experiment whether a puncture is absolutely necessary to insure infection, but some evidence has been obtained that points to a possibility of inoculation without a puncture of the skin. For example on June 21, Royal Ann cherries while still on the tree were smeared with cherry blight exudate, care being taken not to injure the skin. On July 12, just three weeks later, some of these cherries showed small depressions on the surface similar to those originally infected and when placed on sterilized cut pears produced the typical fire blight exudate. The short cherry season prevented fol-

lowing up this suggestion to determine to what extent cherries are so infected. It is quite possible that these particular samples had minute punctures at the beginning although none could be detected with a hand lens. Further work, however, is planned for another year in order to clear up this and other points.

These experiments clearly show that the organism producing the fire blight (*B. amylovorus*), which is so destructive to pears and apples, has also adapted itself to live on the fruit of cherries. It is possible, in fact entirely probable, that under favorable conditions this organism may acquire increased pathogenicity toward this host and attack the tissues as it does in the apple and pear.

The damage done by this cherry blight is as yet comparatively slight, but there are possibilities of it proving a serious menace to cherry culture. Growers should therefore be on their guard lest this phase of fire blight be allowed to gain a strong foot-hold and require drastic action in order to eradicate it, such as has happened in the Yakima Valley with the same disease on the apples and pears.

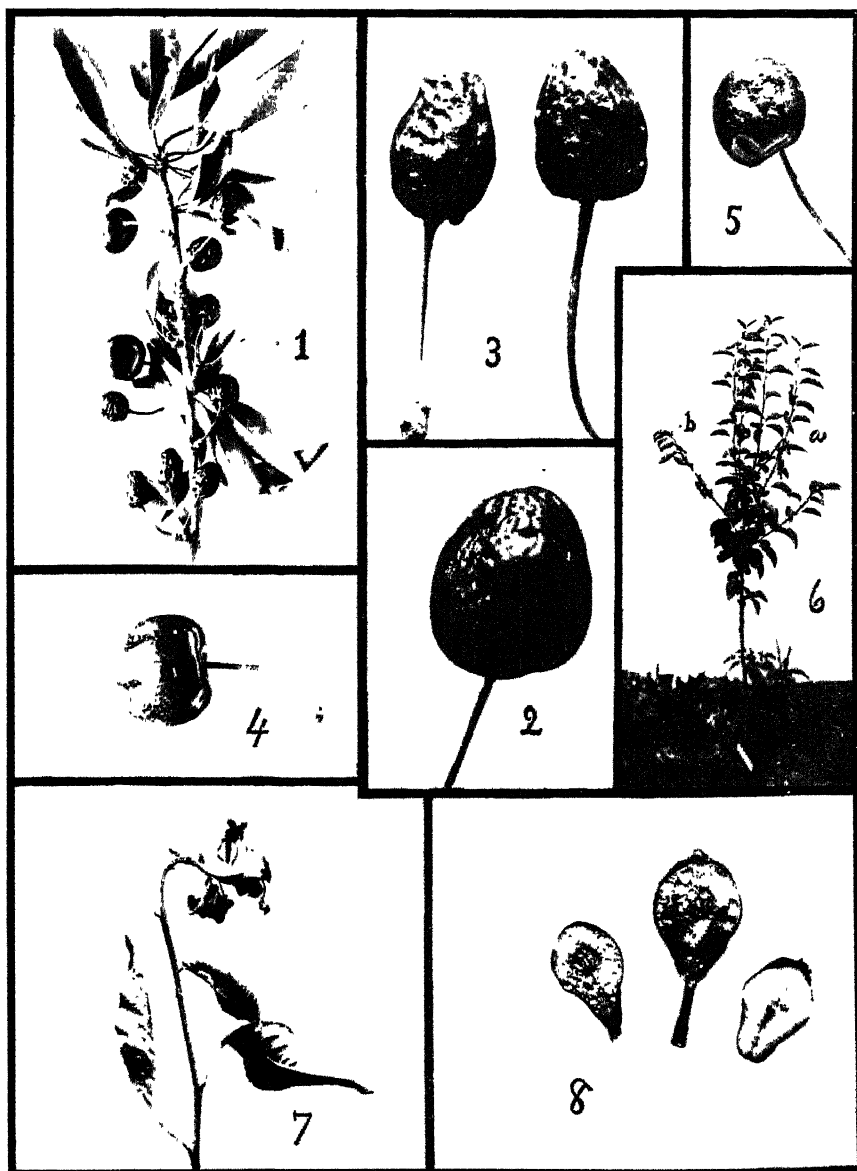
The writer is indebted to Miss Alice Montgomery, Bacteriologist of the Health Department of North Yakima, for plating the organism and obtaining pure cultures of it; also to Mr. Henry Schmitz and Mr. C. E. York for taking the photographs.

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EXPLANATION OF PLATE XIV

- FIG. 1. A branch from a Royal Ann cherry tree showing sound and blighted cherries.
- FIG. 2. Royal Ann cherry slightly affected.
- FIG. 3. Royal Ann cherries showing a more advanced stage of the disease.
- FIG. 4. Shows exudate on a Royal Ann cherry.
- FIG. 5. Shows exudate on a Bing cherry.
- FIG. 6. A Bartlett pear tree showing blighted twigs at *a* and *b*, the result of inoculation with the cherry blight organism.
- FIG. 7. An enlarged view of figure 6, *a*.
- FIG. 8. Gross culture of the cherry blight organism on sterilized cut pears.



HOTSON: FIRE BLIGHT ON CHERRIES

PYTHIACYSTIS INFECTION OF DECIDUOUS NURSERY STOCK

ELIZABETH H. SMITH

WITH FOUR FIGURES IN THE TEXT

The condition in question was first brought to our attention in March, 1914, by H. P. Stabler, Horticultural Commissioner of Sutter County, California, who summoned Prof. R. E. Smith to investigate a case of dying back and gumming of peach nursery stock. As the condition seemed to be general, the matter was turned over to the writer for investigation.

The bark of the affected trees was cankered chiefly above the bud, and in rare cases where the root stock was involved the infection was found to occur by spreading down from above rather than by initial infection at this point. In advanced cases the trunk was completely girdled at about two to six inches above the graft, with the trunk above entirely dead from the combined constriction and infection. In others from one to several smaller cankers occurred, showing as dark, more or less sunken spots, indefinite in outline, often bounded to some extent by the slightly raised concentric lines characteristic of other bark cankers. In the peach the extent of the disease was more clearly seen by removing the outer bark, which revealed a discolored gummy condition of affected spots, while the healthy tissue was white and clean. Pockets of gum often occurred between bark and wood, the gum finally accumulating in masses on the outside. The cankers before girdling averaged three to four inches in length.

The first cultures of *Pythiacystis* were isolated from the Stabler peach material, by inoculating standard agar tubes with a bit of the inner bark or wood from the margin of a canker. The outer bark was first washed with corrosive sublimate and removed with sterile scalpels. Most of the cultures, made in several media, were overrun with yeast, but after ten days an apparently pure growth of a nonseptate fungus was observed in one agar tube. The growth was about three-quarter inch wide about the bit of bark used for inoculation. This later developed sporangia typical of *Pythiacystis citrophthora*,¹ which discharged swarm spores in the characteristic manner.

During March and April of 1914 the same fungus was isolated from almond and pear trees which had been planted the fall previously. The

¹ Smith and Smith. A new fungus of economic importance. Bot. Gaz. 42: 215-221. Sept. 1906.

appearance of the cankers on almond was similar to those on peach. On pear the spread of the disease was very rapid, and when observed the bark was often entirely black from the union for about a foot up the trunk. In March, 1915, the same organism was secured, in the manner described, from plum and almond.

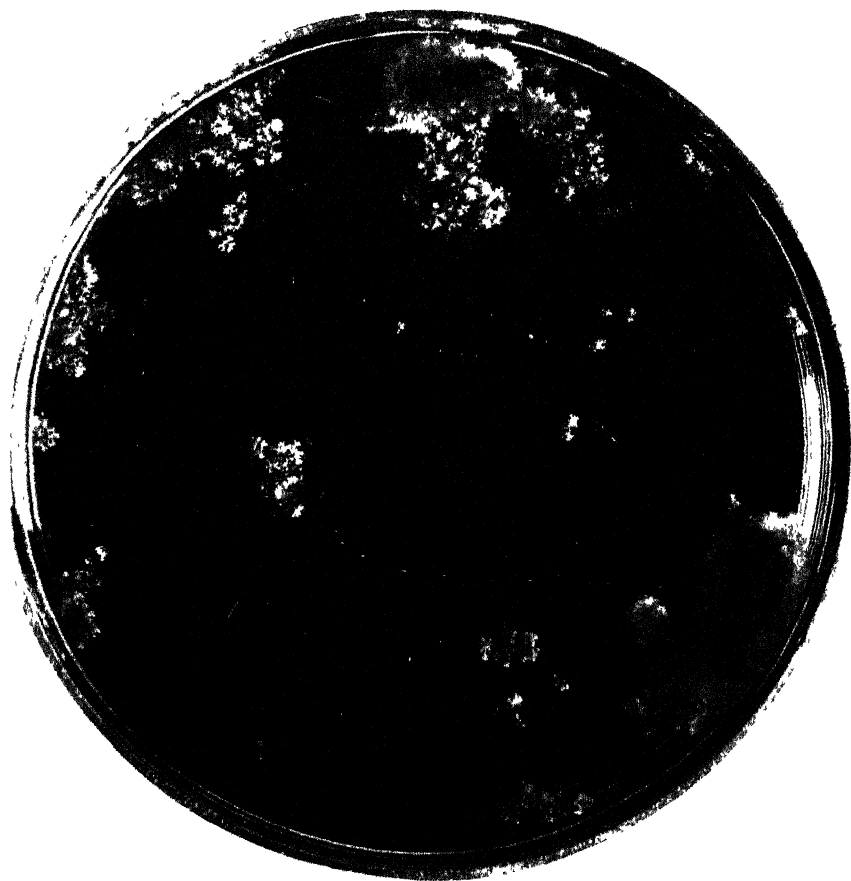


FIG. 1. The fungus in initial dilute prune culture from almond canker.

Of all isolations of the fungus secured, that from almond in 1915 was most satisfactory on account of abundance of material. After securing the fungus from the first specimens submitted, twenty trees from the same orchard were tested for *Pythiacystis*, from eight of which the fungus developed, in some cases in all of (fig. 1) the several cultures made from each tree. In all, the organism has been isolated in eight sets of material

from different points of the Sacramento Valley, and from eight out of twenty trees in the one case just mentioned.

In the winter of 1914-15 successful inoculations from pure cultures of the fungus into potted nursery trees were made as follows:²

1. December 8. Peach strain into apple (Winter Banana and Spitzenburg).
2. December 18. Peach strain into pear, fungus recovered.
3. December 23. Peach strain into pear, 2 trees.
4. December 30. Lemon strain into pear, fungus recovered.
5. January 26. Peach strain into peach (Muir), fungus recovered.
6. January 28. Peach strain into almond, fungus recovered.
7. February 2. Peach strain into pear (Bartlett).
8. February 8. Peach strain into peach (Early Crawford).
9. February 16. Lemon strain into pear (Bartlett).
10. March 12. Plum strain into pear.
11. March 12. Peach into almond into wild peach (probably *P. Davidiana*).
12. March 12. Peach into almond into cherry (Royal Ann).

From all of these inoculations distinct cankers were formed, from one-half inch to one foot in length, while from the checks nothing developed. With one exception, this one inoculation having dried out for lack of moisture, all inoculations tried were successful.

The first inoculations were made by cutting a narrow tongue (about one-half inch long and one-quarter inch wide) in the bark eight or nine inches from the ground, after the surface had been thoroughly washed with mercuric chloride and sterile water. The check was cut in the same way, either on a separate tree or several inches above on the same trunk. A bit of the fungus was then placed in the incision between the bark and wood, both inoculation and check being then tightly bound with a thick wad of sterile cotton three or four inches wide. Both were then saturated with sterile water, and in some of the first cases covered with a glass cage made to fit tightly over the pot. The trees were kept by themselves on an open balcony three stories from the ground and many of the inoculations exposed to constant rain. The cotton was kept moist in all cases by rain, sterile water, or by covering. When the shape of the tree permitted about two feet of glass tubing an inch or two in diameter was forced down over the tree to the ground, one end being buried in the soil and the top plugged with dry sterile cotton. It was found that from the soil circumscribed

² In discussing this paper Professor Fawcett reports the successful inoculation of *P. citrophthora* into peach and apricot trees in connection with his work at Whittier, Calif.

by the tube end sufficient moisture evaporated to keep the lesion moist. If the tube could be forced down only part way on the trunk, the lower end was dry plugged and a bit of moist cotton included.



FIG. 2



FIG. 3



FIG. 4

FIG. 2. Tree No. 7, pear, inoculated with peach strain by needle puncture; after 20 days.

FIG. 3. Tree No. 4, pear, inoculated with lemon strain; after 12 days.

FIG. 4. Tree No. 9, pear, inoculated with lemon strain and left exposed; after 8 days. Note the callus forming at border.

In later cases inoculation was often by needle punctures. In No. 7, for instance, three needle punctures were made just above the bud and about one and one-half inches apart, into the two lower of which a small bit of mycelium was tucked. The upper puncture was used as a check. The covering tube was forced into the earth as described above, the upper

end reaching four inches above the check. The extent of infection could be seen plainly by the blackening of the bark and the development of the cankers was observed from day to day. Within six days the two cankers had merged with no development at check. When the experiment was abandoned after twenty days the combined canker was 8 inches long, involving the check and extending one and one-half inches down into the stock (fig. 2).

As noted in the above list an authentic strain of *Pythiacystis citrophthora* was used to inoculate pear trees in two instances with positive results. In case No. 4, two inoculations with check were made on one tree, the lesions were wrapped and the tree covered with a bell glass. January 12 cankers two and three inches in length and surrounding the trunk were formed at the inoculations, with nothing at check. January 19 the fungus was recovered in culture from the edge of one of these cankers (fig. 3). In case No. 9, February 16, inoculation was by needle puncture and was left without wrapping. February 24 a canker one inch long had developed, with nothing at check (fig. 4). It was raining February 16 to 20.

As in the case of *Pythiacystis* on lemon³ the bark is affected almost uniformly through its entire thickness and remains firm, with no apparent fungous growth on its surface at any stage.

In all typical cases at about the time the cankers become inactive a callus forms, or rather a mealy puffing out of the bark cells as described by several workers under other conditions. A similar occurrence has been noted by the writer in connection with cankers from other causes. The swelling usually begins just beyond the lower point of the visible canker in the shape of a half-moon, and may appear at the upper margin, rarely at the sides.

Several attempts have been made to infect the Eureka lemon and other citrus stock with the peach strain of *Pythiacystis* but so far without success, probably on account of the lateness of the season when tried. Apparently infection is much more rapid under conditions of abundant moisture in deciduous than in citrus bark.³ This experiment will be repeated another season.

During March of 1915 inoculations were made under ordinary conditions in the University nursery. The work was done during rainy weather and just after plowing, while large clods of turf and soil were still thrown up about the trees. Puncture inoculations only were made, with no wrapping. Check trees were punctured in each case. A tabulation follows:

³ Fawcett, H. S. Two fungi as causal agents in gummosis of lemon trees in California. Mo. Bul. State Commission of Hort. 2: no. 8. Also Phytopath. 3: 194-195. 1913.

- March 13. Peach strain into apricot, 3 trees; March 31, 1 positive.
Peach strain into almond, 3 trees; March 31, 1 positive.
- March 31. Almond strain into almond, 3 trees; April 20, 2 positive.
Almond strain into apricot, 7 trees; April 20, 7 positive.
Peach strain into apricot, 5 trees; April 20, 5 positive.

The week following March 13 was very dry, but occasional rains followed until the middle of April. The March 13 cankers were very small, with considerable gumming. All inoculations of April 20 gave small but definite cankers one-half inch or more in diameter with copious gumming. Slight gumming occurred about three checks of April 20, otherwise nothing.

Attempts were made early in the season to inoculate trees at the crown by inoculating the soil about it, but without success. Our observations seem to show that most of our deciduous root stock is more or less immune to this trouble. The disease is probably spread to a large extent either in the nursery or in healing in during the fall before planting. Our attention has been called to the trouble in the spring in every case, when growth fails to start, but the trouble at that time is always at an advanced stage.

So far as tried, no variety of deciduous fruit has failed to contract the disease after inoculation.

During the spring of 1914 a gumming almond tree was submitted, having two cankers about two and six inches above the bud and each about two inches in length, similar in appearance to the peach affection. The upper canker had completely surrounded the trunk.

From this an apparent *Pythiacystis* was isolated. In comparative work, however, it has been found to differ from the prevailing strain in:

- (1) A greater rapidity of growth in culture,
- (2) A much simplified branching of the mycelium as compared with the other strains,
- (3) The ready production of oospores (in about three weeks' time) on agar media,
- (4) In its failure to infect the pear after inoculation, though small cankers were obtained on the almond and the fungus recovered.

The study of this organism is as yet incomplete.⁴

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⁴ Professor Fawcett (l.c.) has observed a similar strain in connection with his work on the lemon gummosis.

A PODOSPORIELLA DISEASE OF GERMINATING WHEAT

P. J. O'GARA

WITH PLATES XV AND XVI

While examining some wheat fields in the Salt Lake Valley during the summer of 1915 it was noted that there was a considerable unevenness of the stand, there being quite a proportion of very weak plants. Observations during the season of 1914 showed that these fields were infested by the wheat straw worm, *Isosoma grande* Riley, and it was at first supposed that the weakened plants had been injured by the larvae of this insect. Careful examination, however, did not reveal the presence of larvae in the unthrifty plants. The wheat plants in the fields mentioned were largely volunteer, although some additional seed had been sown in the fields. It is the practice of many of the wheat farmers in certain districts of the Salt Lake Valley to grow wheat successively in the same field by depending upon the volunteer stand, sometimes adding seed where it is believed that the volunteer stand will not be sufficient to produce a crop. Very often five or six crops are grown on the same tract without any other cultivation than that of discing and harrowing the land. Under such conditions a notable increase in insect infestation and fungous injury to the growing crops is found.

A large number of weakened plants were carefully removed from the soil and taken to the laboratory where it was found that the attacked wheat kernels were infected with a fungus which had apparently destroyed their contents at or near the time of germination. Sections of the diseased kernels indicated that the contents of the kernels had been completely disorganized and the interior occupied by a dark brown septate mycelium. There was no apparent external mycelium covering the grain but the stalks of the fungus, which were often five or six in number, had grown out from the internal mycelium. Pure cultures of the organism were made and it was found that the fruiting was typical in every respect, excepting on nutrient agar or on cultures which tended to become dry too readily. The best culture media were found to be wheat and rice on which the fruiting was always typical. On nutrient agar no stalks were produced and the conidia were formed directly on the mycelium. The mycelium is at first hyaline and later becomes dark brown. Fruiting takes place within two weeks in practically all cases.

The fungus has been found only on the kernels of germinating wheat and has never been found attacking the growing portions of the plant. The fungus is not considered parasitic, since it seems to attack the wheat kernel at or about the time of germination, completely destroying the contents. The wheat seedling is permanently dwarfed and produces few stools by reason of the fact that the proper food supply is wanting in the early stages of growth on account of the total destruction of the contents of the kernel. As a rule these plants seem never to recover, though growing under favorable conditions.

This paper is merely preliminary to one which will be prepared for publication later. Enough work has been done, however, to indicate that the organism causing this injury to germinating wheat is of considerable economic importance.

A search of the literature indicates, in so far as the writer has been able to determine, that this disease has not heretofore been noted and that the organism has not previously been described. As will be seen by the appended description, the fungus clearly belongs to the Stilbaceae and unquestionably belongs to the genus *Podosporiella*. There is in literature only one other species of *Podosporiella*, namely, *P. humilis*, Ell. & Ev., occurring on the foliage of *Garrya veatchii* in California. The specific name *verticillata* is therefore proposed for this organism and a description appended.

Podosporiella verticillata sp. nov.

Mycelium septate, at first white or hyaline, finally becoming brown to dark brown, producing practically no growth external to the wheat kernel, being wholly within the epidermal covering.

Synnemata parenchyma-like (not fibrous), arising from the mycelium within the wheat kernel, 1 to 5 millimeters long by one-fourth to one-half millimeter in diameter, straight or curved, infrequently branched above, cylindrical, rounded at the apex, at first smooth, olivaceous, lighter colored to hyaline at the apex; hyaline within; finally turning brown or black without but remaining hyaline within, producing conidiophores over the entire surface.

Conidiophores straight, irregular or slightly curved, 6 to 10 septate, 250 to 325 by 7 to 8 μ ; apical cell, hyaline, slightly inflated, 8 to 9 μ in diameter, bearing conidia singly or in a single whorl up to 6 in number.

Conidia very variable, spindle or club-shaped, broader toward the base, straight or slightly curved, rounded at the ends, brown, both end-cells shading from brown to light brown or hyaline, 5 to 10 septate; 58 to 130 by 11 to 15 μ .

Habitat in the kernels of germinating wheat, Salt Lake Valley, Utah, U. S. A.

Latin diagnosis. *Mycelio* in semenibus *Tritici vulgari*, epidermide tectis, rarius in superficie vigentis, septatis, primum albis vel hyalinis, deinde brunneis. *Stipitibus* erumpentibus, cellulosi (nec fibrosi), mycelio orientibus, 1-5 mm. alt. x $\frac{1}{4}$ - $\frac{1}{2}$ mm. diam., rectis vel curvulis, superne infrequenter bifurcatis, cylindraceis, apice rotundatis; primum glabris, olivaceis, apice leniter coloratis vel hyalinis, deinde externe brunneis vel atris sed intus hyalinis; ubique conidiophores gerentibus. *Conidiophoris* rectis, irregularibus vel leniter curvulatis, 6-10 septatis, 250-325 x 7-8 μ , cellula apice hyalina, leniter incrassata, 8-9 μ diam., conidium unicum vel ad 6-verticillatim gerentis. *Conidiis* multo variabilis, fusiformibus vel clavatis, basi crassiusculis, utrinque rotundatis, brunneis, 5-10 septatis, 58-130 x 11-15 μ , loculis extimis apice brunneis vel pallide brunneis vel hyalinis.

Hab. in semenibus germinantibus *Tritici vulgari*, Salt Lake Valley, Utah, Am. bor.

DEPARTMENT OF AGRICULTURAL INVESTIGATIONS

AMERICAN SMELTING & REFINING COMPANY

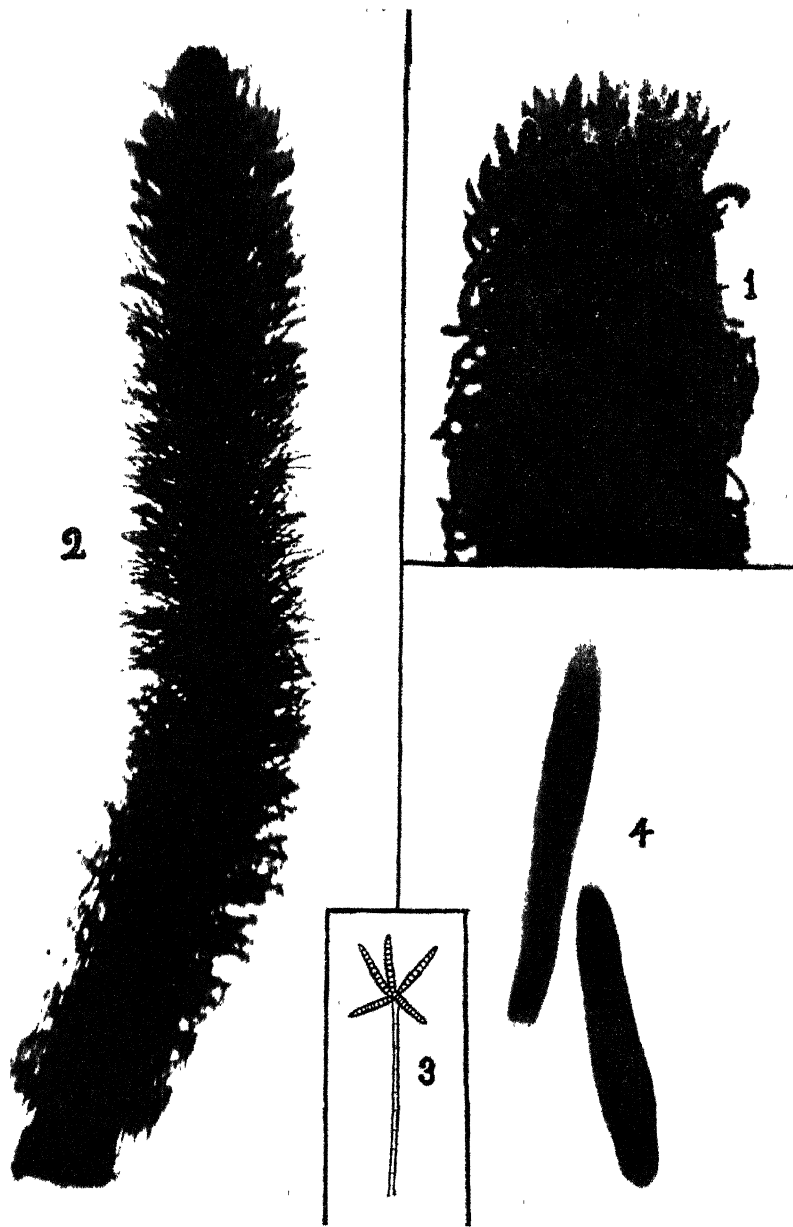
SALT LAKE CITY, UTAH

EXPLANATION OF PLATE XV

Figs. 1 and 2. Wheat plants showing fruiting synnemata or stalks of *Podosporiella verticillata* growing from attacked grains. Natural infection, collected April 13, 1915. Magnified 4 diameters.

Figs. 3 and 4. Wheat grains completely destroyed by *Podosporiella verticillata*. These show very little germination. In figure 3 the wheat grain has been split open lengthwise to show total destruction of contents. The several synnemata were stripped of conidiophores and conidia in removing the kernel from the soil. Natural infection, magnified 4 diameters.

Fig. 5. Pure culture of *Podosporiella verticillata* on nutrient neutral agar, two weeks old. Conidia produced directly from mycelium. No synnemata formed.



O'GARA: *PODOSPORIELLA VERTICILLATA*

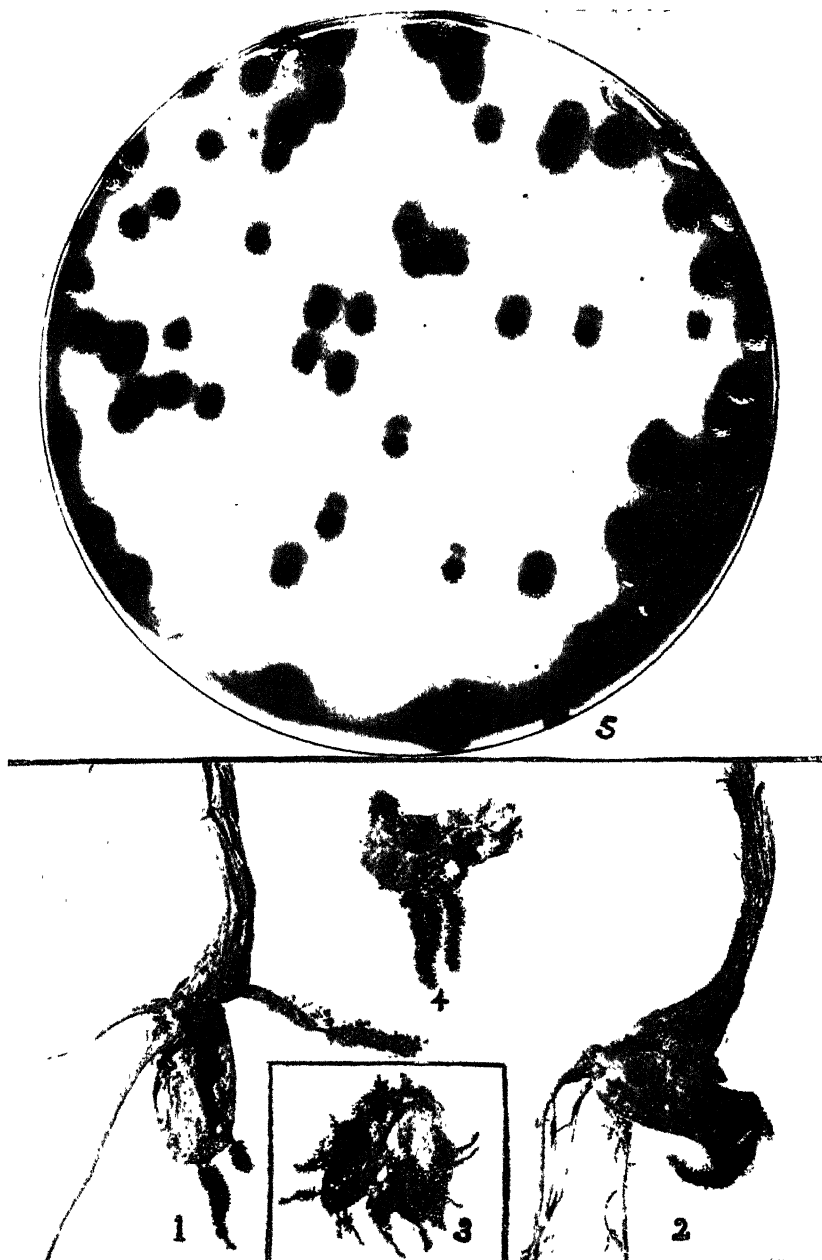
EXPLANATION OF PLATE XVI

FIG. 1. Synnemata of *Podosporiella verticillata* growing on rice. Photograph of upper part of rice tube, magnified $2\frac{1}{2}$ diameters.

FIG. 2. Synnemata or stalk taken from rice culture shown in figure 1. Conidia dropped from the conidiophores in preparation of specimen for photographing. Photomicrograph, magnified 45 diameters.

FIG. 3. Conidiophore with whorl of five conidia attached to apical cell. (Drawing, somewhat diagrammatic).

FIG. 4. Two conidia, from rice culture of figure 1. Septa not shown in photograph due to dark brown color of walls and contents. Photomicrograph, magnified 425 diameters.



O'GARA: *PODOSPORIELLA VERTICILLATA*

NOTES ON THE FIRE BLIGHT DISEASE

V. B. STEWART

Fire blight as influenced by commercial fertilizers

It is the general opinion that cultivation and the application of nitrogenous fertilizer or of any material that tends to induce rapid and succulent growth, favor the serious development of the fire blight disease. The experiments conducted by the writer¹ show that although young pear trees growing in sod are susceptible to fire blight and may become infected, they are, on the other hand, less liable to attack by the blight bacteria than trees which have been manured and well cultivated. The application of commercial fertilizers to certain soils undoubtedly favors the fire blight disease by increasing the succulence of the trees. On the other hand, there is no evidence to show that the fertilizers influence the blight when applied to well tilled soil which already has sufficient amounts of the necessary plant food constituents to insure a good growth of the trees. Does the presence of excessive amounts of the various chemical compounds in the soil cause a physiological change in the tissues which tends to break down the resistance of the tree to blight? With this question in mind an experiment was conducted on nursery ground from the spring of 1911 until the autumn of 1914. The soil was clay loam and had been under cultivation for several years. No commercial fertilizers had been applied, but in the spring of 1909 an application of stable manure was made when the ground was planted to rose stocks. The roses, which made a good growth throughout the next two seasons, were dug in the autumn of 1910.

The ground for the experiment was divided into four plats fifty feet long by twenty feet wide. A space six feet in width separated each plat from the others and in each plat thirty French grown pear seedlings were planted.

The amounts of fertilizers recommended for pear trees at that time by Prof. U. P. Hedrick of the Geneva Agricultural Experiment Station were fifty pounds per acre of actual nitrogen, fifty pounds of phosphoric acid and one hundred pounds of potash. To secure these amounts per acre the following was suggested: Three hundred and fifty pounds of dried

¹ Stewart, V. B. The fire blight disease in nursery stock. New York (Cornell) Agr. Exp. Sta. Bul. 329: 347-350. 1913.

blood plus one hundred pounds of nitrate of soda to obtain the nitrogen; three hundred and fifty pounds of acid phosphate to obtain the phosphoric acid and two hundred pounds of muriate of potash to supply the potash.

The above constituents were applied as follows: To plat I nitrogen, at the rate of fifty pounds per acre; to plat II phosphoric acid, at the rate of fifty pounds per acre plus potash at the rate of one hundred pounds per acre; to plat III were applied nitrogen, phosphoric acid and potash at the rate of fifty, fifty and one hundred pounds per acre, respectively; to plat IV no fertilizers were added.

The fertilizers were applied in the spring at about the time the trees developed the first new leaves. The materials were spread over the plats and raked into the soil. No weeds were allowed to grow in any of the plats and all were cultivated three times during the summer.

In a few cases there was apparent injury to the trees due to the fertilizers applied, particularly in the nitrogen and phosphoric acid plats. This injury is attributed to poor distribution of the fertilizer in the soil, it being applied too closely to the trees. In the month of August all of the seedlings which had made a suitable growth were budded to Bartlett pears.

The following spring (1912) the seedlings were snagged (all of the growth was removed above the point in the trunk of the seedling at which the Bartlett bud was inserted the previous summer) and most of the buds started to grow, continuing their development throughout the season. No fertilizers were applied during the year 1912 but all the plats were cultivated four times that season.

Several of the trees were killed during the winter of 1912-1913 by low temperatures and others were girdled by rodents, however, there remained about twenty trees in each plat which were not injured. The fertilizers were again applied in the spring of 1913 to the different plats, the same amounts being used as in 1911. The trees were cultivated four times during the summer and all made a good growth, appearing to be somewhat larger and more succulent at the end of the season, than the average two-years-old budded pear stock in the nursery rows. But little difference could be noticed in the growth of the trees in the different plats except that those in the nitrogen plat were, on an average, slightly larger than the others.

The plats again received the same amounts of fertilizers in the spring of 1914 and were cultivated four times. On July 7 five trees in the central area of each plat were inoculated with a two-days-old bouillon culture of *Bacillus amylovorus* (Burr) Trev. The inoculations were made by immersing the point of a needle in the bouillon culture and pricking the tips of three young, tender shoots on each tree. Three days later many of the

infections were apparent at the tips of the shoots and within a period of five days all the inoculated shoots except one showed fire blight infections. No difference could be noticed as to resistance of the trees to blight in the different plats. The slight increase in growth of the trees in the nitrogen plat did not materially affect the blight. Also in this experiment, at least, there was no evidence to verify the opinion that the application of phosphates and potash tends to harden the tissue of the trees, making them more resistant to fire blight.

No attempt was made to remove the affected shoots and within the short period of three weeks most of the inoculated trees were ruined. The blight had extended down the branches to the trunks and girdled the trees causing their destruction. Many natural infections occurred after the inoculated shoots became diseased and practically none of the trees in any of the plats were free from blight on July 24. The trees appeared to be exceedingly succulent and the progress of the blight was very rapid. By August 20 all of the trees were ruined, those trees in the check plats being as susceptible to the disease as trees which had been fertilized.

During the four seasons that the above experiment was continued, the trees received a normal amount of precipitation each year, which, along with proper cultivation, afforded them ideal conditions for growth. Any marked effects on the trees caused by the application of the fertilizers should have been readily apparent. On the other hand, sufficient growth was made by the trees in the check plat to indicate that the fertilizers were not necessary additions to the soil in order to greatly influence the growth of the trees. Under such conditions the presence of the fertilizers in the soil had no apparent effect on the inherent qualities of the trees with respect to their resistance to the attacks of the fire blight bacteria.

Pears resistant to fire blight

Fire blight is known to be more destructive in certain varieties of pear trees than in others and within recent years particular mention has been made of several comparatively new varieties which have shown special resistance to the attacks of the fire blight bacteria. In most cases these varieties have practically no value commercially, however, certain horticulturists have suggested the possibility of using these pears for developing varieties that are immune to fire blight and which also possess good edible qualities. Investigations along this line have already been reported by Reimer² of California and Hansen³ of South Dakota.

² Reimer, F. C. Blight resistance in pears and pear stocks. California Hort. Com. Mo. Bul. 4: 145-149. 1915.

³ Hansen, N. E. Breeding pears immune to blight. South Dakota Agr. Exp. Sta. Bul. 159: 187-191. 1915.

With such pears that have not been affected by fire blight it is of interest to determine whether the trees are resistant to the disease owing to the characteristic growth of the tissue which checks the activities of the bacteria or whether they are really immune to fire blight by virtue of certain inherent qualities which prevent the bacteria from becoming established in the tissue of the trees. The greatest chance of obtaining a suitable pear that is resistant to blight is by crossing one of the standard commercial varieties with a pear that is known to be absolutely immune to the disease. The problem becomes more difficult when the crossing is done with a variety that is only resistant and not entirely immune. So far as is known no variety which has been thoroughly tested, has proved immune to the disease under all conditions.

The Douglass variety which originated as a seedling of the Kieffer pear, probably crossed with the Angoulême has received special attention as a resistant variety. According to the advertisements of A. H. Griesa, Lawrence, Kansas who originated the Douglass pear this variety has been growing in central Kansas for fourteen years and although fire blight has been very prevalent in that region the Douglass pear has never been known to blight. In order to test the resistance to blight of this pear, three two-years-old trees were planted in the disease garden at Ithaca, New York, in the spring of 1914. At this time Mr. Griesa also sent a tree of the variety Abraham which was planted near the Douglass trees.

In the autumn of 1914 Dr. F. A. Wolfe of the Alabama Polytechnic Institute asked the writer to test a variety of pear which appeared to be resistant to fire blight in Alabama. According to the pomologist of the United States Department of Agriculture, the variety originated as a seedling from the Japanese or Chinese Sand pear, *Pyrus sinensis*. Six two-years-old nursery trees of this variety were received in the spring of 1915 and planted near the Douglass pear trees mentioned above.

On May 1, 1915, the Douglas trees had developed numerous new shoots and there were present also several blossom clusters which were just opening. The shoots were about three to four inches in length and very succulent. The following inoculations were made with a three-days-old agar culture of *Bacillus amylovorus* isolated from an apple twig in the summer of 1914:

(1) A camel's hair brush moistened with water was smeared with the agar culture and then carefully brushed over the stigma and pistil of five blossoms. (2) The tissues of five other blossoms were pricked with a needle which had been dipped into the agar culture. (3) The tips of six Bartlett shoots and six Douglass shoots were inoculated by means of the needle smeared with the agar culture. (4) The tips of three Douglass shoots and three Bartlett shoots were injured with a sterile needle for checks on the inoculations.

On May 13 all of the inoculated blossoms were affected and the blight was extending down the pedicles. The extent of the lesions was slightly more marked in the tissue which had been injured than in the blossoms inoculated by means of the brush. Four of the inoculated Douglass shoots became diseased and five of the Bartlett shoots blighted; the infections had extended about three inches down the shoots. None of the twigs blighted which had been injured with a sterile needle.

Varietal inoculations were made May 26, 1915, with a two-days-old bouillon culture of *Bacillus amylovorus* isolated from apple in 1914. The new shoots on the trees at this date averaged about six inches in length and appeared to be relatively succulent. The following varieties were inoculated by pricking the tips of the shoots with a needle which had been dipped into the culture: five shoots on each of two Douglass trees; five shoots on one Abraham tree; three shoots on each of two Bartlett trees; three shoots on each of two Sand pear trees.

The first infections appeared June 23 but many of the inoculated shoots failed to blight at all. The progress of the blight in the affected shoots was slow and the damage slight, none of the trees was severely injured. Most of the infections dried up and did not extend down the shoots for a distance of more than three or four inches. This was particularly true of the Douglass trees. The failure of the infections to become destructive is attributed to the extremely dry weather which prevailed throughout May and June. The lack of precipitation impeded the growth of the young shoots which had developed, making the tissue hard and woody and more resistant to the activities of the blight bacteria.

On June 19 inoculations were again made with a two-days-old bouillon culture of *Bacillus amylovorus*. The growth of the trees still showed the effects of the dry weather but in general the shoots were fairly succulent and appeared to be suitable for inoculating. The new growth of the Sand Pear and Abraham trees was slightly more tender than that of the Bartlett and Douglass varieties. Several shoots on each of four Bartlett, one Abraham, four Sand Pear and three Douglass trees were inoculated.

On June 27 the first infections appeared and two days later several others were apparent, but some of the inoculated shoots never blighted. The progress of the blight in the affected twigs was slow and none of the trees was seriously damaged by the disease. On July 6 a few of the infections had extended down the shoots into the old wood, forming cankers two to three inches in length. These cankers were apparent on some of the trees of all varieties except the Douglass. The shoots of this variety were not affected so severely and the blight never reached the main branches of the trees.

In spite of the numerous small cankers formed none of the trees suffered to any extent and when observed July 25 new buds were developing from

points immediately below the affected areas. A sharp line of demarcation separated the healthy and blighted tissue.

The failure of the blight to severely affect the trees was attributed as in previous inoculations, to the dry weather throughout May and June which caused the trees to make a comparatively slow growth. Although there was heavy rainfall from June 30 to July 6 the effect of a large amount of precipitation on the growth of the trees was not apparent until the blight had run its course and all of the infections were dried out. Frequent observations were made throughout the season but none of the cankers became active again. An attempt to isolate the causal organism from two lesions on August 5 gave negative results.

On July 28 another series of inoculations were made with the same trees used in previous experiments. An average of four shoots were inoculated in each tree. Favored by the heavy precipitation which occurred during the month of July the trees were growing rapidly, many of the shoots being two to three feet in length. Six days after the inoculations were made the first infections appeared and in general the blight was more destructive than in all former inoculations. This was especially true of the Sand Pear trees; in practically every case the infections extended the entire length of the long tender shoots but the disease was not so destructive in the older branches. Numerous cankers were formed in the larger limbs and branches of the Bartlett and Abraham trees. The Douglass trees showed the greatest resistance. None of the shoots was entirely affected by the blight and its extent down the twigs was considerably less than in the other varieties. After August 20 there was a tendency for the tissues of all the varieties to harden and become more mature, thus checking the blight for the remainder of the season.

From the above inoculations it is apparent that none of the varieties tested are immune to fire blight. On the other hand the Douglass variety is affected less severely than the Bartlett trees or the young shoots of the Sand Pear trees. This, however, is attributed to the characteristic growth of the Douglass trees rather than to the presence of any inherent qualities which tend to make the trees immune. The young tender tissue of the Douglass variety is apparently as susceptible as of any other pear but the tendency for the tissue to rapidly harden, soon after it is formed, impedes the activities of the blight bacteria and the injury is less severe. The fact that the inoculations into blossoms gave one hundred per cent infection indicates that during a season favorable for blossom-blight, heavy losses might occur in a Douglass pear orchard owing to the destruction of the fruit by blossom-blight. It is well known also that fire blight cankers are not so destructive in the old limbs and branches of Sand Pears, however, the inoculations, along with the observations of certain

horticulturists, show that under ideal conditions for the disease, severe injury may occur to the new growth that develops during the season. The succulence of shoots which develop so rapidly makes them very susceptible to the blight. On the other hand the tissue hardens very rapidly and the older branches are therefore considerably more resistant to the disease.

With such varieties as the Douglass and Sand Pear, material is afforded for developing a suitable pear, that will have considerable resistance to fire blight, but the chances appear to be limited of producing a pear which is entirely immune.

It is of interest to note also that the results of the inoculation experiments discussed above are in accordance with the fire blight conditions which existed in New York State during the past season. Although an unusually severe epiphytotic of the disease occurred in 1914, the losses from blossom and twig-blight were comparatively small in 1915. This condition is attributed to the extremely dry weather which prevailed throughout the early part of the season of 1915; there was very little precipitation previous to July 1. The reduced water supply actually prevented a rapid growth of the trees in many cases with the result that the tissue was not so susceptible to the attacks of the fire blight bacteria. This point is well illustrated by the failure of infections produced artificially in the experimental trees, to become destructive. Also many of the hold-over cankers in blighted trees were less active on account of the dry weather and did not exude the gummy substance which is a source for new infections, especially blossom-blight, early in the season. After the middle of July, when there was an excessive rainfall for the remainder of the season, many of the cankers became more active and fire blight was much more prevalent.

Fire blight favored by a hail storm

The unusual prevalence of the fire blight disease in the orchards and nurseries of New York State throughout the summer of 1914 afforded an opportunity to observe the disease under many conditions. Of particular interest was an outbreak of fire blight in a two-years-old nursery block of Bartlett pear trees which being under high cultivation and favored by ideal growing conditions had made a rapid and succulent growth. On July 30 a severe hail storm occurred which caused considerable damage. Wherever the hailstones struck the pear trees the tender succulent bark was easily broken, producing small wounds in the tissue. The following day it was noticed that many insects of all kinds, especially flies, were attracted to these wounds to feed on the exuding sap.

An occasional infection of fire blight had been found in the pear trees previous to this time and in a nearby apple orchard twig blight was very common. On August 12, two weeks after the hailstorm, the injuries in the bark caused by the hailstones had begun to heal over to a considerable degree, but in many cases fire blight cankers were apparent on the trunks and branches of the trees. A large number of these blight infections appeared to have originated in the wounds of the bark made by the hailstones. All indications point to the fact that the blight bacteria were carried to the wounds by the insects which visited the trees to feed on the exuding sap. The injuries afforded the bacteria an entrance into the tissue and owing to the succulence of the trees the blight lesions developed very rapidly. Many of the trees were soon girdled and completely ruined.

A similar instance occurred also in a four-years-old pear orchard which had been well cultivated throughout the summer. This orchard which consisted of about fifteen hundred trees was also in the path of the hailstorm and approximately three miles distant from the nursery trees mentioned above. Previous to the storm considerable fire blight had appeared in a large apple and pear orchard nearby but only very little blight had been noticed in the four-years-old pear trees. On the other hand several days after the hail storm numerous infections of fire blight were apparent on the trunks and limbs of these small trees and in many cases it was evident that the infections originated at the points of injury in the bark made by the hailstones. Most of the trees were saved from destruction by removing the affected branches but where infections occurred on the trunks of the trees the eradication of the disease was more difficult. About sixty of the trees were girdled and ruined by fire blight cankers which developed around wounds in the bark produced by the hailstones.

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CONNECTION OF A BACTERIAL ORGANISM WITH CURLY LEAF OF THE SUGAR BEET

RALPH E. SMITH AND P. A. BONCQUET

WITH PLATE XVII AND ONE FIGURE IN THE TEXT

In a recent communication upon this peculiar disease published in this JOURNAL¹ we pointed out the presence of a specific lesion showing itself in the phloem of the fibro-vascular bundles of all affected plants or parts of plants. We also mentioned the fact of having isolated a certain bacterial organism from all affected parts of sugar beet plants, which organism appeared to be a constant inhabitant of affected tissues. We also mentioned the detection with the microscope in the lesions above mentioned of certain bodies, apparently of the nature of foreign organisms but of an undetermined nature.

Lesion. Figures 1 and 3 of Plate XVII in the present article show the location and appearance of the characteristic lesions in a freehand section of a living sugar beet petiole, stained with dilute neutral red. In figure 2, Plate XVII, is shown a microtome section of a beet root with considerably advanced lesions in the phloem. These diseased tissue areas correspond with the black spots seen with the eye when the root of a curly leaf beet is cut across.

Organisms in tissues. A large amount of histological work performed since our last article was written has shown that these lesions in all parts of affected plants, even out to the most minute, youngest vascular bundles in the leaves, are constantly inhabited by a specific bacterial organism. This organism, furthermore, has the remarkable habit of living within the cells, inhabiting the sieve-tubes of the phloem and forming therein a ring or layer just inside the wall. In figure 4 Plate XVII is shown a cross section of part of a leaf vein phloem containing a young curly leaf lesion. In the sieve-tube indicated by the arrow a circle of bacteria-like bodies may be seen lining the wall. These are shown more clearly in the longitudinal section in figure 5. Since these photographs were made many more sections have been cut and examined and the fact established beyond any possible doubt that we have in the sugar beet disease a foreign organism living abundantly in the interior of the sieve-tubes. In appearance the organism shows itself mainly in two rather distinct forms, as may

¹Phytopath. 5: 103. 1915.

be seen in the photographs. In one of these forms there are symmetrical, ring-like bodies with a comparatively thick wall. Individuals of the other form are elongated with a dense portion at each end. Intermediate between these two are forms which consist of a slightly oval ring with a thickening at each end. The bi-polar forms average 1.1 by $1\ \mu$ in size.



FIG. 1. Young sugar beet plant, typically affected with curly leaf.

with the smallest about 0.7 by $0.5\ \mu$. The ring form tends to be fairly large with a diameter often equalling the greatest length of the bi-polar individuals. These bodies are somewhat refractory to the usual bacterial staining methods, but vigorous stains like Leishman's and Giemsa bring them out quite easily. For temporary purposes dilute neutral red

is effective. For staining paraffin sections on the slide we have come to prefer the gold chloride method, treating first for 12 hours with 1 per cent gold chloride, then for 12 hours with 0.25 per cent formic acid; all in the dark and with very thorough washing in water between the two chemicals and after the treatment.

It was thought for a time that the ring and bi-polar bodies might represent two different organisms, but further study makes it appear that all the individuals have the same structure, varying in appearance with the position in which they happen to lie. For a long time we were unable to establish to our own satisfaction any connection between the bodies or organisms seen with the microscope and that isolated from the same tissue in cultures. The latter, as we mentioned in our previous article, seems to resemble *Bacillus dianthi* Bolley and, for convenience, we will call it by this name for the present, at least. Grown in ordinary media *B. dianthi* is a typical rod-shaped organism with a strong tendency to the formation of zoogloea. By growing this organism in special media, however, particularly in 0.5 per cent lithium chloride in nutrient bouillon, we have succeeded in exactly reproducing in great abundance the bi-polar form seen in the tissue, and a small proportion of individuals of the ring form, although we have not yet in cultures obtained the latter in any such abundance as it occurs in the tissues. Sufficient results have been obtained along this line to convince us strongly that we are dealing with one and the same organism throughout the whole matter.

Bacillus dianthi as a sieve-tube inhabitant of the sugar beet not peculiar to the curly leaf disease. For some time after the discovery of the remarkable presence of this organism in the sieve-tubes of curly top affected beets, we were inclined to assume that the specific incitant of the disease had been found and that the effect of the insect *Eutettix tenella* Baker upon the sugar beet was an act of infection with this organism. Further study, however, in an effort to determine exactly the limits of this disease, has revealed the surprising fact that *B. dianthi* inhabits the sieve-tubes of sugar beets and related plants very commonly in cases where there is no possibility of the plants ever having been attacked by *Eutettix tenella* and cases which cannot be considered as representing this particular disease. The fact was early noticed in our work that there exist in sugar, garden and stock beets, Swiss chard and similar plants a great variety of foliage types representing various forms of wrinkling, curling and distortion. Many or in fact most of these forms represent nothing which could be called a pathological condition except in the strictest sense of the word. Such plants grow and develop normally but show many forms of curled, roughened and distorted leaves, as may be seen by an examina-

tion of any garden or field containing these plants. Through histological study of all sorts of types of distorted beet foliage growing in California the discovery has been made that in all these cases *Bacillus dianthi* inhabits the sieve-tubes to a greater or less extent and that the abundance of this organism corresponds directly with the degree of abnormality or distortion showing itself in the foliage. In a perfectly smooth beet leaf with all portions symmetrically developed and with the main lateral veins proceeding symmetrically and at the same angle from the mid-vein, careful search fails to reveal the presence of *B. dianthi*. In wrinkled, curled, or distorted leaves, however, the organism has been found in the veins adjacent to such distortion and even in the main root of the plant. It was thought for a time that plants with these various types of foliage represented various types of the real curly leaf disease induced by *Eutettix tenella*. Subsequently, however, plants which had been grown from the seed in very carefully protected cases and with no seeming possibility of access of this insect, revealed the same condition.

At this point the senior author, in order to settle the fact beyond question, made a trip to various Eastern localities for the purpose of obtaining beet material far beyond the known range of *Eutettix tenella*, the eastern limit of which is supposed to be considerably west of the Mississippi River. Sugar beets, garden and stock beets, and various forms of Swiss chard were found and examined in the sugar beet districts of southeastern Michigan and northwestern Ohio, and also at Amherst, Massachusetts. In these districts no trace of typical curly leaf was found, but practically all other types of distorted or unsymmetrical beet foliage previously observed in California were encountered in abundance. Upon our return to California preserved material was sectioned and examined whereupon the fact developed that *Bacillus dianthi* was common in the sieve tubes of all these plants and here again varying in abundance with the degree of morphological abnormality of the leaves.

From this it appears certain that the incitation of curly leaf in sugar beets by *Eutettix tenella* is not necessarily an act of infection with this organism, or at least that the presence of *B. dianthi* in the sieve-tubes is not the only factor necessary to produce curly leaf. At the same time the organism has a certain pathological effect and the problem of the etiology of the curly leaf is very greatly complicated by the fact of its occurrence. It would appear that the insect must either increase the virulence of *B. dianthi* in some manner, or else it introduces an entirely different factor.

A horticultural variety of beet produced by Bacillus dianthi. One of the most interesting results of our study is connected with a certain variety of beet, specimens of which were found growing upon the grounds of the Massachusetts Agricultural College at Amherst. This is the so-called

"lettuce leaved" beet, apparently a form of chard, with large, very much curled or wrinkled leaves, similar to those of the Savoy cabbage. Sections of the petiole and veins of these leaves have shown that the sieve-tubes are full of the organism which we are calling *Bacillus dianthi*. Such being the case, it is natural to connect the extreme roughening or wrinkling of the leaves with the remarkable abundance of the organism in the tissues, and conclude that this variety owes its peculiar type of foliage entirely to the presence of this foreign organism.

Bacillus dianthi in beet seed. Our search for this organism in the tissues of sugar beets has followed up the development of seed stalks, blossoms and seed and we have found that in beets with decidedly distorted foliage the development of the organism in the sieve-tubes keeps pace with the growth of the plant and that the foreign invader may be found high up in the seed stalk many feet from the ground, in the lateral branches, in the pedicels of the blossoms, and actually in the vascular tissue of the seed itself. This fact would seem to indicate that the organism may be carried over in the seed and find its way into the new plants from this source rather than from exterior infection. This would likewise account for the perpetuation of the "lettuce leaved" type or variety of beet mentioned above which apparently comes true from seed.

Inoculations. All our efforts to produce curly leaf or any pathological or abnormal condition in sugar beets by artificial inoculation, either with the juice of diseased plants or with cultures of *Bacillus dianthi*, have thus far entirely failed. Attempts have been made by atomizing material upon uninjured surfaces, through large and small wounds in the leaves, petioles and roots, and by inserting the material into various parts of the plant in capillary glass tubes which were broken off and allowed to remain in the tissue. These inoculations have been made at various degrees of temperature and humidity, but all without effect.

Transmission by grafting. Curly leaf has been easily and typically produced in healthy plants by grafting into the top of the root pieces of the root of an infected plant, with growing buds attached.

Eutettix tenella from wild plants not pathogenic. In another article contained in this number of Phytopathology Messrs. Boncquet and Hartung announce the important discovery that when taken from wild plants far removed from beet fields *Eutettix tenella* has no effect upon sugar beets, but is able to produce the typical disease only after feeding upon plants which have the disease. In our own work this fact has been extensively tested and abundantly corroborated. Fully two thousand insects obtained from the Tulare Lake region, California, from *Atriplex tularensis* Jepson, and *Chenopodium album* L., have been tested out upon several hundred different sugar beet plants without the production of curly leaf or any

other visible effect in a single instance. After feeding upon curly leaf sugar beets, however, for a period which at most need not exceed three hours, the same insects become highly pathogenic. It is of course altogether possible that some other wild plant than the one from which we obtained our insects may harbor the pathogenic factor, but it seems at least to be demonstrated that this factor is not inherent in the insect but must be obtained by it through feeding upon plants affected with curly leaf, or at least those containing a factor which incites this disease.

Incubation period in the body of the insect necessary. Many experiments have been tried of allowing the insects to feed upon curly leaf sugar beets for various lengths of time, then moving them on to healthy plants and transferring from plant to plant at various intervals in order to determine how quickly the insect can become infectious after feeding upon the diseased plants. We have found, as mentioned in the last paragraph, that no more than three hours feeding time is necessary for the insect to obtain the pathogenic factor. All the experiments tried thus far, however, go to show that the insect is not immediately pathogenic after the act of feeding, but that a period of at least twenty-four hours, but certainly not much more than this, must elapse before it can produce the disease. In one experiment, for instance, twenty-five wild insects (which had previously been feeding upon healthy sugar beet plants without any effect upon them) were allowed to remain for three hours upon a curly leaf plant. They were then transferred singly to twenty-five healthy plants, the insect upon each plant being confined to one leaf in a small glass tube. At the end of three hours each insect was removed and placed upon a new plant, again after a period of twenty-one hours had elapsed, and again after twenty-four hours more. After this the insects, now reduced to eighteen in number, remained upon the same plants for six days. Each set of plants was kept at all times, from the planting of the seed to the conclusion of the experiment, in Eutettix-proof cases. In the twenty-five plants upon which the insects passed the first three hours after feeding for three hours upon a diseased plant, and among the same number of plants upon which they passed the following twenty-one hours, no effect whatever was produced. Of the twenty-five which were used during the second twenty-four hour period three became typically affected with curly leaf after the usual period of twelve to fourteen days. Of the eighteen plants upon which the insects remained for six days commencing forty-eight hours after they first fed upon the diseased plant, eight became affected.

Several other experiments along the same line have given the same indication, namely that Eutettix does not mechanically transfer the pathogenic factor from diseased to healthy plants but that some development

or change takes place in the factor within the body of the insect during the first few hours after it feeds upon the diseased plant. A great many experiments have been made which show that no more than forty-eight, and possibly not over twenty-four, hours is necessary for the insect to become pathogenic.

Credit is due to Mr. H. A. Lee for carrying out the details of much of the work described in this article, and for many helpful suggestions in connection with the same.

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PLATE XVII. HISTOLOGICAL CONDITIONS OF CURLY LEAF DISEASE

FIGS. 1 and 3. Curly leaf lesion in phloem of sugar beet leaf veins.

FIG. 2. As in figure 1. Microtome section, more enlarged.

FIG. 4. *Bacillus dianthi* in sieve tubes.

FIG. 5. *Bacillus dianthi* in longitudinal section of sieve tube.



SMITH AND BONCQUET: CURLY LEAF DISEASE

INSECT CONTROL IMPORTANT IN CHECKING FIRE BLIGHT

A. C. BURRILL

The important part played by insects in the dissemination of plant disease pathogenes is each year becoming more evident. It has therefore seemed worth while to give some attention to this from an entomological viewpoint, especially with reference to fire blight, since the writer is convinced that the control of the insect carriers offers the easiest way to check the blight. The writer's interests at the outset were chiefly with aphids, but as his results will show, he has found that other Homoptera, leaf hoppers, may play an important part. Although trials were planned before the writer knew of Stewart's latest work along these lines, especially with Heteroptera (1, 2, 3), he wishes to record his indebtedness to Stewart's published reports for further suggestions, as well as to the earlier one of Jones (4). Stewart plated *Bacillus amylovorus* successfully from aphids which had fed on blighting shoots of apple, thus showing that the aphids may function as germ carriers. He further observed that in apple nurseries, fire blight epidemics follow rapidly in the wake of aphid epidemics.

EXPERIMENTAL STUDIES

It seemed practicable to study the habits of aphids and leaf hoppers more closely in relation to the spread of blight under Wisconsin conditions. The wild crab apple¹ which is common about Madison blights badly and is infested with various apple insects. It was therefore chosen for experimental study, in a field where both adult trees and sprouts, or seedlings, occur. Madison had a severe blight epidemic in 1914 which included a first attack in a week of humid hot weather in early June, a second in the hot muggy week of July 4, and further minor outbreaks during several muggy dogday periods in August. Throughout this growing period, none of the seedlings blighted, but on the adult trees in June those water sprouts blighted which had aphids.² Therefore seedlings which appeared blight-

¹ *Pyrus coronaria* L. intermediate with *P. ioensis* (Wood) Bailey.

² *Aphis avenae* Fab. and *A. mali* De Geer often intermingled on the same shoot and tended by an ant *Formica rufa* subsp. *obscuripes* Forel (?). J. J. Davis, United States Bureau of Entomology, examined microscopic slides of aphids taken from these same trees the preceding fall and pronounced them *Myzus persicae* Sulz., an illustration of the many changes in aphid population on a given tree during a single year.

free were chosen for some colonization experiments. Seedlings, four to six feet high, were covered with glazed paper sacks (glasseen), each arranged to cover two or more twigs, so as to give sufficient controls in each trial. Within two of these glasseen bags, a terminal shoot was further isolated in a mica chimney closed at each end by tightly-fitting aseptic gauze bands, so that aphids could not pass through. A small amount of moist cotton was placed in each bag with the idea that the moist atmosphere might favor the growth of the blight germ.

On the larger crab trees, badly blighting leaves infested with living aphids were carefully chosen. Such a leaf with aphids was placed in each mica tube, and the aphids left to find their way from the shrivelling leaf to the fresh twig adjacent. All other insects had been brushed off these twigs before they were enclosed in the bags. The same method was applied to leaf hoppers (*Empoasca mali* LeBaron) except that they were caught in paraffined capsules and liberated on the bagged test twig after the bag was in place. In an attempt to make a test parallel with the trial of leaf hoppers the writer was unsuccessful in a search of an hour in securing a single tarnished plant bug, *Lygus pratensis* L., in the weeds which were abundant all about the crab trees.

These trials were started June 19, and the results were recorded June 30, 1914. In experiments 1 and 2, a mica tube contained the insects and twig on which blight was expected, while other twigs, outside of the tube but within the bag served as useful controls both because no insects were present and because the effect of a bag with wet cotton needed to be compared with unenclosed shoots.

Experiment 1. Winged and apterous aphids on blighting leaf enclosed in mica tube. Result, eight inches of test twig blighted. Controls in bag outside mica chimney remained healthy.

Experiment 2. Apterous aphids on blighting leaf enclosed in mica tube. Result, one to two inches of test twig blighted. Control twigs did not blight.

Experiment 3. Apterous aphids similarly enclosed in bag, no tube. Result indefinite, since twig had three leaves with browning tips nearly as in blight, and four more leaves yellowing, the latter not adjacent to each other. Controls outside of bag, no blight or abnormality.

Experiment 4. Apterous aphids moved to a blighting leaf and in a few hours returned to the original blight-free twig from which they were taken; enclosed in bag, no tube. Result, six to ten inches of test twig blighted. As the aphids were not confined by mica tubes in this and the last test, it was not surprising to find several leaves on adjacent twigs within the bag which were partly discolored, suggesting infections when the aphids retreated from the blighting terminal shoot. No blight on

twigs outside bag. The blight resulting as reported above seems to show immediate infectivity by aphid carriers.

Experiment 5. Winged and apterous aphids enclosed as in Experiment number 3. Result, two to six inches of each of several test twigs blighted within bag, no blight without. The blighted twigs were mostly laterals near base of main shoots, where most aphids had located after test began. However, the main shoots showed no blight though aphids occurred near tips. The main shoots may have had more mature tissues.

Experiment 6. Enclosed as in number 4. Aphids from an apparently healthy aphid-infested twig placed on a blighted aphid-free leaf so that they could wander back to former twig. Two leaf hoppers were present on healthy twig and were so enclosed with the aphids. Result, one to three inches on each of several test twigs blighted within the bag but none outside the bag, although some of these controls continued to be infested with aphids. Unlike Experiment 4, both lateral and terminal twigs blighted.

Experiment 7. Two leaf hoppers, from blighted leaves of crab apple, and a blighting twig transferred to an apparently healthy twig which was already infested by two other leaf hoppers supposedly uninfected. Result, four inches of test twig blighted. Twigs immediately adjacent to test twig at point where bag was tied, but outside bag, seemed affected. All other shoots and twigs of seedling seemed healthy.

DISCUSSION OF EXPERIMENTAL RESULTS

Where mica tubes were used, no twigs blighted within the bag save in the tube, thus showing that the moist chamber made by the bag did not induce blight but that blight occurred only where insects, known to have sucked from half-blighted leaves, were confined.

In experiments 4 and 6 aphids were sought from apparently uninfected twigs. It may be assumed that the aphids were previously uninfected. The right to this assumption is based on the fact that no other parts of the young tree on which they also occurred developed blight. This clean colony occupied many other twigs which served for checks.

Experiment 7 shows that leaf hoppers may act as carriers of blight and, judging from observations on these insects while inspecting nurseries during the last five years, the writer believes that they are the most important carriers of blight in Wisconsin during July and August.

CONCLUSIONS

The chief problems of fire blight transmission and consequently of its control center about the question as to what species of insects most com-

monly carry blight and as to what times such species are abundant during May, June, and July, the chief months for blight. In this connection it is noteworthy that fire blight according to observations appears in waves or definite maxima during the early growing period of some fruits, and the attempt has been made to correlate with these waves corresponding waves of development of sucking insects predatory upon the trees.

Waite (5) has shown that bees and probably wasps and flies carry blight while working upon the flowers. Following this period various other observers have attributed the further spread of the organisms to the winged green apple aphid (6) and to bark borers (4) in the orchard, to the tarnished plant bug and some other Heteroptera (3) in the nursery (2), to apple tree borers in apple collar blight in Pennsylvania (7), and to click beetles and ants as well as to the drip of rains in California orchards (8). The writer's tests add *Aphis avnae* and *Empoasca mali* to the list, from which many other suspected insect species are purposely excluded. These two species were chosen as the most common insects on Wisconsin apple trees. The writer does not doubt Stewart's finding tarnished plant bugs, *Lygus pratensis* L., most abundant on New York apple trees during July,³ but is unable to prove that his conclusions hold for Wisconsin, since this tarnished plant bug is not the most important sucking insect in the nursery⁴ until August. In July, the month he seeks to correlate these bugs with blight, there are in Wisconsin, hosts of leaf hoppers on apple nursery stock. If these observations for the respective states prove indisputable, a further problem presents itself as to how widely conditions vary in different states or environments with regard to the dominant species of sucking insects and how great is their fluctuation in numbers from year to year and at different times in the year. In this connection, none of the writers seem to emphasize the fact that few hibernated tarnished plant bugs and leaf hoppers appear at the time of the opening of the buds and blossoms. With them the writer fails to conceive how so few can account for the multitudinous early infections beyond admitting their probable rôle as first carriers of blight. The tarnished plant bug feeds on many weeds and can less often transmit germs directly to other apple shoots on account of intermediate feedings on weeds. In contrast, apple leaf hoppers are more strictly limited as to host plant. In Wisconsin nurseries and orchards, leaf hoppers and aphids are far more abundant than tarnished plant bugs. Several field observations in 1914, in other parts of Wisconsin, seem to support the tests and the theory involved above, but are omitted for lack of numerical data.

³Especially nursery trees. Stewart (2), p. 340.

⁴Stewart (2), p. 368.

Weather conditions seem to correlate with blight waves and insect waves. For example, late frosts may stop blight by killing aphids and buds as happened on April 23, 1910, in Wisconsin. Frost-free backward springs foster insect emergence and retard blossoming until large numbers of blight-carriers are at hand to infect the trees, according to Reed (9).

If further evidence supports this view, the control of insect carriers of blight must prove far cheaper than the present method of tree to tree pruning, which is not only expensive but at the best only partially effective. I do not wish, however, to imply that we should relax our attempts to eliminate hold-over cankers, a subject still much in need of study.

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PHYTOPATHOLOGICAL NOTES

The comparative effect upon sugar beets of Eutettix tenella Baker from wild plants and from curly top beets. The writers desire to report the following experiment as throwing valuable light upon the relation of *Eutettix tenella* to the curly leaf disease.

One hundred specimens of *E. tenella* obtained from the Tulare Lake region of California in May and June, 1915, were confined singly upon normal sugar beet seedlings. At the same time about one hundred and fifty individuals which had been living upon curly leaf sugar beets at Spreckels, California (where this experiment was made), were similarly



FIG. 1. Comparative effect upon sugar beets of *Eutettix* from *Atriplex tularenensis* and from curly top beets. In plat *D* one insect from diseased beet was placed upon each plant. In plat *B* there was a similar application of *Eutettix* from *Atriplex*. Almost every plant in *D* badly affected with curly top, in *B* no trace of the disease.

confined upon healthy plants. The latter promptly produced very severe typical curly leaf upon almost every plant in a most decided fashion. The wild insects had no effect whatever and the beets are still in normal condition. Sixty of the wild insects were removed from these plants after remaining upon them for three weeks and placed upon other beets badly affected with curly leaf. They were then removed from those plants at different times after remaining upon them for a period of from three to seven days and placed upon other normal plants. At least fifty of the latter are at the present time typically affected with curly leaf, while the remaining ten are somewhat doubtful. About twenty wild insects have been kept constantly upon normal beets since May without showing any effect whatever. These experiments show most strikingly that the wild insects used, coming from *Artemisia* or *Atroplex* species in the Upper San Joaquin Valley, had absolutely no power to produce curly leaf, while similar insects reared at Spreckels upon diseased beets were extremely pathogenic. They also show that the wild insects become pathogenic after feeding for a few days upon affected plants.

P. A. BONCQUET AND WM. J. HARTUNG

Mildew on black currants. On July 10, 1915, a block of black currant nursery stock was noticed to be severely affected with mildew. Although several of the larger nurseries in New York State have been visited many times each season for the past seven years, this is the first infection of mildew ever observed by the writer on black currant, *Ribes nigrum*. All of the varieties, Champion, Naples and Saunders, in the block were affected and several adjoining rows of red currants, *Ribes rubrum*, also were slightly attacked. The black currants were separated from a large block of Downing and Industry gooseberries by a driveway thirty feet wide. Although a careful search was made on this date no infections of mildew were apparent on any of the gooseberry bushes. On August 27, a single infected shoot was found on an Industry bush at a distance of about one hundred feet from the black currants; this was the only infection which appeared on the gooseberries throughout the summer.

The general characteristics and measurements of the fungus found on the currants are in accordance with those of *Sphaerotheca mors-uvae* (Schw.) B. & C., which is commonly found on gooseberries; and Salmon has reported this species as attacking red and black currants in Europe. Assuming that the same species of mildew affects both currants and gooseberries, the writer is unable to account for the absence of the mildew on the gooseberries, particularly on the very susceptible variety Industry, except on the basis of biological specialization.

V. B. STEWART

Citrus mildew. Mr. C. N. Carter's¹ paper on a powdery mildew on citrus in your issue of June, 1915, has induced me to send you the accompanying rough notes on citrus mildew in the hope that they may be of interest to American phytopathologists.

In Ceylon, and, I am given to understand, in India also, mildew of citrus is a common disease. Indeed, in Ceylon it is the worst disease of citrus we have.

It was first recorded for Ceylon by Berkeley² in *The Gardeners' Chronicle*, n. s., I, p. 477 (1874), as follows:

"It is now some years since we received from Lieut-Colonel Grant, of Wellington, Neilgherries (i.e., South India—T. P.) some leaves of Orange and Mango which were infested with the Oidiod form of some *Erysiphe*. . . . Our attention has lately been recalled to the subject by a sprig of Orange from Mooloya, Hewahette, Ceylon (4000 feet), sent by Dr. Thwaites under No. 1230, too late to be included in the account of Ceylon Fungi lately published in the *Journal of the Linnean Society*. The Wellington specimens exhibit, except in one minute spot, nothing more than a form of *Oidium* with rather long, almost truncate joints. In the Ceylon specimen there is a trace of these though most have been absorbed, and in their place a multitude of both conidio-morphic and spherical pycnidia, pouring out a profusion of stylospores, exactly as in the figure which Tulasne³ gives in his *Carpologia* I, tab. V, fig. 3. It is most probable therefore that the species is one of the forms of *Erysiphe communis*, and it is the more interesting because the genus is not hitherto recorded as occurring in the Eastern Indies or the neighboring islands. The perfect fruit has not yet been found. As the vine mildew has extended to tropical climates and is capable of being propagated on other plants it becomes a matter of interest to inquire whether the parasite in question is not identical and whether it has not been introduced with it."

The pycnidia noted by Berkeley are of course those of *Cicinnobolus*, which is especially common on mildews in Ceylon. We have in Ceylon both *Plasmopara viticola* and the conidial stage of *Uncinula spiralis*, both no doubt introduced, but oidia are so general on native plants that there is no need to consider Berkeley's suggestion.

Mildew of citrus has since been recorded for Ceylon in numerous reports, etc., intended for local information, and in the Annual Reports

¹ Carter, C. N. A powdery mildew on citrus. *Phytopathology* 5, no. 3:193-196, p. 12. June, 1915.

² Berkeley, J. M. *Gard. Chron.* n. s. 1, no. 15:477-478. April 11, 1874.

³ Tulasne, L. R., and Tulasne, Charles. *Selecta Fungorum Carpologia* 1: pl. 5, fig. 3. Parisii, 1861.

of the Mycologist. In the Year Book of the Ceylon Agricultural Society,⁴ it is stated, "Orange and other citrus trees in Ceylon are specially subject to diseases, one of the commonest of which is a mildew which covers the leaves and young shoots with a thick white coating. This usually occurs toward the close of each monsoon, and in some districts kills back the shoots so regularly that the trees never grow up."

As citrus cultivation is of no importance in Ceylon, work on this disease has been shelved in favor of more urgent investigations. The disease occurs on varieties of sweet orange, and on mandarin, but is especially destructive on pomelo (= grape fruit). I have not observed it on Lime, which is common in Ceylon, or on lemon or citron, which are rare. On the older leaves the appearance of the disease is similar to that described by Mr. Carter: the leaves are attacked locally, and ultimately exhibit only effused blackened areas; they do not necessarily fall off. On the young shoot, however, the effect is more serious; the young leaves and the stem may be densely covered with a white powder, and the shoot ultimately killed back for a length of about a foot. Where this occurs after almost every monsoon, i.e., every six months, as it does in some localities, the trees never grow up, but form only low stunted bushes which either die out or are uprooted by the owner in disgust.

Measurements of the conidia of the Ceylon species give 36 to 42 by 15 to 18 μ as the dimensions, as against 20 to 28 by 10 to 15 μ given by Carter. It is probable therefore that the Ceylon fungus is a different species. In the absence of any experiments, it is also possible that the forms on the various species of citrus in Ceylon are not all the same. But in any case it seems desirable to put on record that mildew (*Oidium*) of citrus is a well-known and wide-spread disease, or group of diseases, in Ceylon, and thus to indicate the possibility of its introduction into America.

The cultivation of citrus fruits is, for various reasons, not a commercial proposition in Ceylon. But were Ceylon in other respects suited for it, the prevalence of mildew would practically render it impossible.

Contrary to the opinions generally expressed, mildews, or at least their *Oidium* stages, are common in the Eastern tropics. It is frequently stated that in the tropics *Meliola* replaces *Erysiphe*. So far as Ceylon is concerned that is not true: species of both genera are common. But no perithecial stage of *Erysiphe* has yet been found in Ceylon. It may be noted that the occurrence of *Meliola* is, in part if not altogether, conditioned by the presence of insects which secrete "honey dew," and cannot be considered as antithetical to the occurrence of *Erysiphe*.

⁴ Petch, T. Notes on fungus diseases. Yearbook Ceylon Agr. Soc. 1914/15: 65-67. 1914.

As possibly bearing upon the citrus mildew, it may be recorded that an *Oidium* has been found on *Aegle marmelos*, a native species of Rutaceae. Of interest in another direction is the fact that oak trees (*Quercus pedunculata*), grown in the hill district of Ceylon from seed imported from England, have been attacked every year since the writer has known them. (i.e., since 1904), and probably earlier, by an *Oidium*, and in consequence are merely scrub. Another species is prevalent on tobacco. Collections of *Oidia* from Ceylon, including the citrus mildew, have been submitted to European specialists from time to time during the last twenty years, but the latter have preferred to demand the production of perithecia rather than refer the conidial stages to any species. Specimens of the *Oidium* on *Quercus* have been contributed to Sydow's *Fungi Exotici Exsiccati*.

T. PETCH

Personals. Prof. H. M. Jennison, assistant professor of Botany and Bacteriology in the Montana Agricultural College, Bozeman, Montana, will do graduate work during the ensuing year at the Missouri Botanical Gardens while on leave of absence. Address Missouri Botanical Gardens, St. Louis, Mo.

Dr. George Osner, field assistant in Pathology in the Bureau of Plant Industry*, stationed at Plymouth, Indiana, has been appointed associate botanist in the Indiana Experiment Station at Purdue University, Lafayette, and has entered upon his duties.

LITERATURE ON AMERICAN PLANT DISEASES¹

COMPILED BY MISS E. R. OBERLY, LIBRARIAN, BUREAU OF PLANT INDUSTRY

August to September

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- Anderson, Jacob Peter.** Fungus diseases. *Alaska Agr. Expt. Sta. Rpt.* 1914: 26-27. 1915.
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- Ashby, S. F.** Notes on diseases of cultivated crops observed in 1913-14. *Bul. Dept. Agr. Jamaica n. s.* 2, no. 8: 299-327, pl. 62-63. August, 1915.
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¹ This list aims to include the publications of North and South America, the West India Islands, and islands controlled by the United States, and articles by American writers appearing in foreign journals.

All authors are urged to cooperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agric., Washington, D. C.

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ERRATA FOR VOLUME V

- Page 150 line 2, for rötliche read röhliche.
Page 150 line 7, for ohnlich read ähnlich.
Page 153 line 1, for Sphaecelotheca read Sphacelotheca.
Page 186 line 2, for *Zizania aquatica* L. & *Z. palustris* L., read *Zizania aquatica* L. and *Z. palustris* L.
Page 217 line 22, omit trouble.
Page 283 line 8, for Pathologist read Physiologist.
Pages 244 and 289, for Franklin Lincoln Stevens read Frank Lincoln Stevens.
Pages 263 and 264, interchange legends for figures 2 and 3.
In explanation of Plate XVI, fig. 2, for synnemata read synnema.
Page 326, interchange legends for Plates XV and XVI.
Page 349 line 13, for Atroplex read Atriplex.

